HOV POOLED FUND STUDY

HOV Lane Eligibility Requirements and Operating Hours Handbook

Final Annotated Outline (*3/15*/05)

Overview of the Annotated Outline

The HOV Lane Eligibility Requirements and Operating Hours Handbook contains eight chapters and four appendices. This document contains the *final* annotated outline. It contains more detailed information that the Draft Annotated Outline. The comments and suggestions provided by *Neil Spiller, the FHWA COTR, and Eldon Jacobson of WSDOT have been addressed and other sections have been expanded*. *In addition, examples of the icons and text for the chapters at a glance, key points, good ideas, and case studies are provided. The new text is presented in script.*

The following chapters are proposed for the handbook.

Chapter One – Guide to the HOV Lane Eligibility Requirements and Operating Hours Handbook
Chapter Two – Executive Summary
Chapter Three – Background and Planning for Operations
Chapter Four – Assessing Vehicle Eligibility Requirements
Chapter Five – Assessing Vehicle-Occupancy Requirements
Chapter Six – Assessing HOV Operating Hours
Chapter Seven – Performance Monitoring and Policy Implications
Chapter Eight – Case Studies
Appendix A – References and Additional Resources
Appendix B – Glossary of Terms
Appendix C – List of Abbreviations
Appendix D – Agency Contacts

Chapter One – Guide to the HOV Lane Eligibility Requirements and Operating Hours Handbook

I. Welcome to the High-Occupancy Vehicle Lane Eligibility Requirements and Operating Hours Handbook

Welcome to the HOV Lane Eligibility Requirements and Operating Hours Handbook. This handbook provides a comprehensive guide to assessing the potential impacts of changes in eligibility requirements and operating hours on high-occupancy vehicle facilities. While the handbook focuses on assessing potential changes in the operation of existing HOV lanes, it may also be used in planning new HOV facilities.

The handbook is intended to meet the needs of various audiences. The primary audience of the handbook is transportation professionals responsible for planning, designing, funding, operating, enforcing, and managing HOV facilities. The secondary audience includes agency management personnel, policy makers, and other individuals interested in the effective and efficient operation of HOV lanes.

The development of the HOV Lane Eligibility Requirements and Operating Hours Handbook is sponsored by the HOV Pooled Fund Study (PFS) group and the Federal Highway Administration (FHWA). Participating state transportation agencies include California, Georgia, Maryland, Massachusetts, New Jersey, New York, Tennessee, Virginia, and Washington. This handbook represents one of the projects sponsored by the PFS group. Other handbooks of use to transportation professionals and policy makers sponsored by the PFS group include the HOV Performance Monitoring, Evaluation, and Reporting Handbook, the HOV Lane Safety Considerations Handbook, and the HOV Lane Enforcement Handbook.

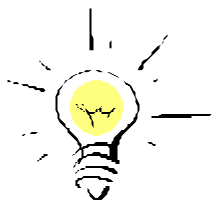
The goal of the HOV Pooled-Fund Study (HOV PFS) is to assemble regional, state, and local agencies, and the Federal Highway Administration (FHWA) to

- identify issues that are common among agencies;
- suggest projects and initiatives;
- select and initiate projects intended to address identified issues;
- disseminate results; and
- assist in solution deployment.

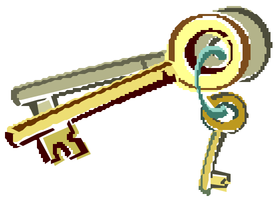
Participating state transportation agencies include California, Georgia, Maryland, Massachusetts, New Jersey, New York, Tennessee, Virginia, and Washington.

The handbook includes a number of user-friendly features. The following icons are used throughout the handbook to highlight the handbook at-a-glance and chapters-at-a-glance, good ideas, keys to successful practices, and case study examples.

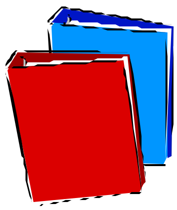
– *Highlights handbook at-a-glance and chapter at-a-glance.*



– *Highlights good ideas based on experience with establishing and changing vehicle eligibility requirements, occupancy levels, and operating hours.*



– *Highlights keys to successful practices related to vehicle eligibility requirements, occupancy levels, and operating hours.*



– *Highlights case study examples of the experience and results of changing vehicle eligibility requirements, occupancy levels, and operating hours. More detailed information on the case studies is provided in Chapter Eight.*

II. Federal Interest in Operational Changes

FHWA has periodically issued guidance on HOV facilities. *Federal funding is typically used to support the design, right-of-way acquisition, construction, and operation of freeway HOV lanes. The FHWA Program Guidance on HOV Operations in intended to help protect the federal investment in these facilities and to promote the efficient use of HOV lanes while maintaining the intent of maximizing the person-movement capacity of these facilities. As noted in the Program Guidance, the source of federal funds used on an HOV project will influence the ability to make changes in the operation of the facility. Some funding categories cannot be used for additional general-purpose roadway capacity. These categories include the Congestion Mitigation and Air Quality (CMAQ) program, the Interstate Maintenance Program, and Mass Transit Capital Investment Grants. Other federal funding sources may have requirements that limit consideration of possible changes in user groups or operating strategies.*

The most recent Program Guidance on HOV Operations was issued on March 28, 2001. The Program Guidance identifies the circumstances under which federal action is required to initiate changes in the operation of an HOV facility, and the federal review process and requirements to be used in these situations. The Program Guidance is available on the FHWA Internet site at http://www.fhwa.dot.gov/legsregs/directives /policy/index.htm.

Federal action is required when significant changes are proposed to existing HOV facilities constructed with federal funds. Significant changes include major alterations in operating hours and converting an HOV lane to general purpose use. Minor modifications in operating hours and changing from different multi-person occupancy levels (from 3+ to 2+, for example) do not require federal approval. Coordination and consultation with FHWA is appropriate even when an operational change is only being considered or discussed, however, as a basis to determine what may be needed for actual changes to occur.

The Program Guidance identifies the information to be included as part of a federal review. Examples of needed information include original studies and plans for the HOV facility, project agreements, commitments made in the environmental process, operational assessments, analysis of future conditions, examination of alternative operating scenarios, and possible impacts on air quality levels and plans. The Program Guidance further outlines the federal review requirements related to air quality conformity, the state implementation plan, the congestion management system, the National Environmental Policy Act (NEPA) process, and other issues.

The Program Guidance and other available documents support the need to examine HOV systems on a regional, not just individual project, basis. Elements in this approach include a multi-year regional HOV system strategic plan, which is integrated into the metropolitan area long-range plan, and a multi-agency program to manage implementation of the system plan and to support day-to-day operation of HOV facilities and supporting services. This approach allows for the long-term regional commitment for infrastructure improvements, the careful phasing of operating segments, and coordinating the development and operation of supporting services, facilities, and policies.

III. Chapters At-a-Glance—Finding What You Need

The HOV Lane Eligibility Requirements and Operating Hours Handbook is divided into the following eight chapters.

Chapter One – Guide to the HOV Lane Eligibility Requirements and Operating Hours Handbook
This chapter introduces the HOV Eligibility Requirements and Operating Hours Handbook and presents the chapters-at-a-glance.

Chapter Two – Executive Summary
This chapter provides a summary of the handbook. It starts with an overview of HOV facilities and the relationship of HOV lanes to other elements of the transportation system. The major topics addressed in the remaining chapters are highlighted. These topics include planning for operations and assessing vehicle eligibility requirements, vehicle-occupancy requirements, and HOV operating hours. Information on performance monitoring and policy implications is also presented. The primary audience for the chapter is policy makers and agency management personnel, although it is appropriate for all groups interested in HOV facilities.

Chapter Three – Background and Planning for Operations
This chapter provides a background to operating HOV facilities and highlights activities that should be completed prior to opening a facility. These elements include identifying the goals, objectives, and measures of effectiveness (MOE) to be used for assessing the performance of an HOV lane, developing an operations plan, establishing a performance monitoring and evaluation plan, and creating an operations management team.

Chapter Four – Assessing Vehicle Eligibility Requirements
This chapter highlights the types of vehicles usually considered for use of an HOV facility. The advantages of allowing different vehicles are highlighted along with some of the issues associated with various user groups. Techniques for assessing the potential demand based on different vehicle requirements are presented.

Chapter Five – Assessing Vehicle-Occupancy Requirements
This chapter provides an overview of possible vehicle-occupancy requirements. The advantages and limitations of different occupancy requirements are summarized. Techniques to assess potential changes in vehicle-occupancy requirements are presented.

Chapter Six – Assessing HOV Operating Hours

This chapter describes the different hours of operation scenarios typically used with HOV facilities. The advantages and limitations of different operating scenarios are discussed. Factors which may influence consideration of HOV operating hours are highlighted. Techniques to assess possible changes in HOV operating hours are presented.

Chapter Seven – Performance Monitoring and Policy Implications

This chapter describes the ongoing monitoring of HOV facilities and the importance of linking current performance to the project goals, objectives, and measures of effectiveness discussed in Chapter Three. Possible issues that may be encountered with operating HOV facilities are highlighted, along with potential policy implications.

Chapter Eight – Case Studies

This chapter highlights case study examples related to changing vehicle eligibility requirements, vehicle-occupancy levels, and operating hours. The case studies provide available information on the impact of different approaches, including HOT lanes and value pricing, environmentally friendly vehicles, and changes in occupancy requirements and operating hours.

Appendix A – References and Additional Resources

This appendix contains the references used in the handbook. It also provides additional resources related to topics associated with HOV vehicle eligibility requirements and operating hours.

Appendix B – Glossary of Terms

This appendix contains a glossary of terms associated with HOV vehicle eligibility requirements and operating hours. It focuses on terms used in the handbook.

Appendix C – List of Abbreviations

This appendix contains a list of abbreviations associated with HOV vehicle eligibility requirements and operating hours.

Appendix D – Agency Contacts

This appendix contains telephone numbers, e-mail addresses, and websites for agency personnel responsible for HOV planning and operations.

Chapter Two – Executive Summary

This chapter provides an overview of the complete handbook. It starts with a summary of HOV facilities in operation in North America. It highlights the role of HOV lanes, the types of facilities in operation, and the eligibility requirements and operating hours currently in use. It summarizes the techniques for assessing potential changes in HOV eligibility regulations and operating hours. It highlights issues that may be incurred in operating HOV facilities and provides a link to performance monitoring and policy assessments.

The executive summary is intended primarily for agency management personnel and policy makers. It also provides a useful overview for technical staff.

I. Defining HOV Facilities

HOV facilities represent one approach used in metropolitan areas throughout the country to help improve the people-moving capacity rather than vehicle-moving capacity of congested freeway corridors. Increasing the people-moving capacity helps optimize the efficiency and effectiveness of highway transportation infrastructure investments. The travel time savings and improved trip time reliability offered by HOV facilities provide incentives for individuals to change from driving alone to carpooling, vanpooling, or riding the bus.

High-occupancy vehicle (HOV) facilities are lanes or roadways that are designed and/or operated to provide priority treatment to buses, vanpools, carpools, and other eligible vehicles. Examples of HOV facilities include bus-only roadways, freeway lanes reserved for HOVs, bypass lanes at metered freeway entrance ramps, and special lanes on arterial streets. Although differing in design and operation, high-occupancy vehicle facilities share a similar purpose of helping to maximize the person-carrying capacity of congested roadways.

The development and operation of HOV facilities have evolved over the past 30 years. The opening of the bus-only lane on the Shirley Highway (I-395) in northern Virginia/Washington, D.C. in 1969, the contraflow bus lane on the approach to New York-New Jersey's Lincoln Tunnel in 1970, and the El Monte Busway *on the San Bernardino Freeway* in Los Angeles in 1973, represent the first freeway HOV applications in the country. Today there are some 130 HOV freeway projects in the 31 metropolitan areas in North America highlighted in Figure 1.

HOV facilities are developed and operated to provide buses, carpools, and vanpools with travel time savings and more predictable travel times to encourage individuals to choose one of these modes over driving alone. As illustrated in Figure 2, the person movement capacity of a roadway increases when more people are carried in fewer vehicles. HOV facilities are usually found in heavily congested corridors where the physical and financial feasibility of expanding the roadway is limited. Supporting services, facilities, and incentives are also used to further encourage individuals to carpool, vanpool, or ride the bus.

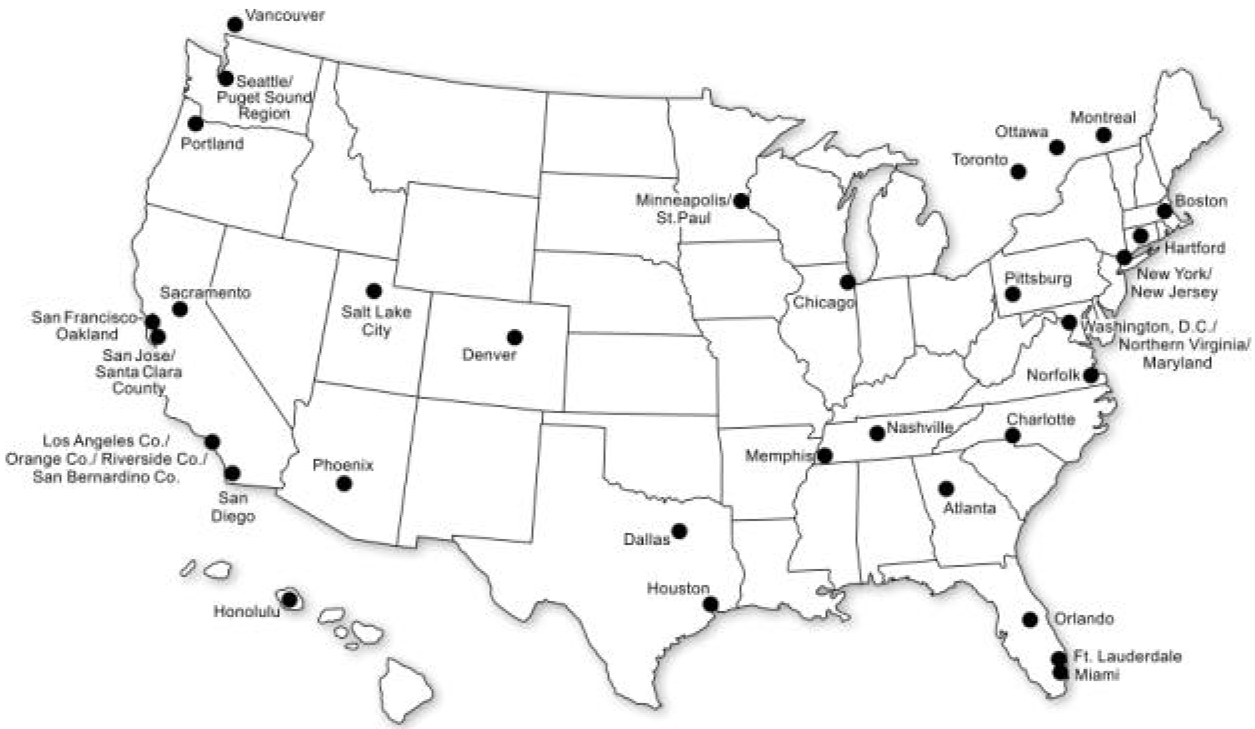


Figure 1. Metropolitan Areas with Freeway HOV Facilities.

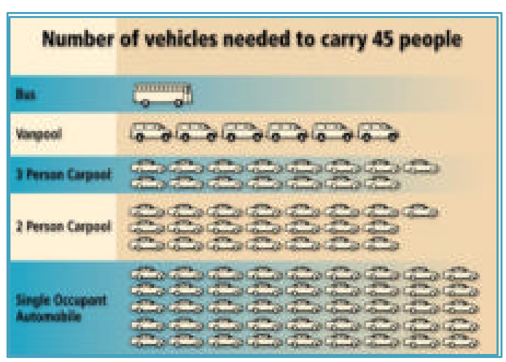


Figure 2. Number of Vehicles Needed to Carry 45 People.

Rather than creating disincentives to discourage drivers who travel alone, HOV lanes are developed to provide a cost-effective travel alternative that commuters will find attractive enough to change from driving alone to taking the bus, carpooling, or vanpooling. HOV projects typically focus on meeting one or more of the following three common objectives.

- **Increase the Average Number of Persons Per Vehicle**. HOV projects focus on increasing the average number of people per vehicle on the roadway or travel corridor by moving people, rather than vehicles. The travel time savings and travel time reliability provided by HOV facilities offer incentives for individuals to change from driving alone to riding the bus, vanpooling, or carpooling. HOV lanes must provide enough travel time savings to offset any additional time that may be needed to pick up and drop off carpoolers or to take the bus.

- **Preserve the Person-Movement Capacity of the Roadway**. HOV lanes, which may move two to five times as many persons as a general-purpose lane, have the potential to double the people-moving capacity of a roadway during peak travel periods. Also, the vehicle occupancy requirements can be raised if a lane becomes too congested, helping to ensure that travel time savings and travel time reliability are maintained.

- **Enhance Bus Transit Operations**. Bus travel times, schedule adherence, and vehicle and labor productivity may all improve as a result of an HOV facility, helping attract new bus riders and enhancing transit cost effectiveness. Many transit agencies have expanded or initiated express bus services in conjunction with HOV facilities.

HOV facilities on freeways or in separate rights-of-way are typically classified into four categories (4). These categories are described below and illustrated in Figure 3.

- **Busway or Exclusive HOV Facility, Separate Right-of-Way**. A roadway or lane(s) developed in a separate right-of-way and designated for the exclusive use by high-occupancy vehicles. *Some times the separate right-of-way for busways is located within a freeway right-of-way.* Most facilities of this type are designed and utilized by buses only. Most are two-lane, two-direction facilities. Busways are in operation in Pittsburgh, Miami, Minneapolis/St. Paul, *Seattle,* and Ottawa, Canada.

- **Exclusive HOV Facility, Freeway Right-of-Way**. A lane(s) constructed within the freeway right-of-way that is physically separated from the general purpose freeway lanes and used exclusively by HOVs for all, or a portion, of the day. Most exclusive HOV facilities are physically separated from the general purpose freeway lanes through the use of a concrete barrier, but a few facilities are separated by a wide painted buffer. Facilities of this type are usually open to buses, vanpools, and carpools. Exclusive HOV lanes are in operation in Houston, northern Virginia, Minneapolis, San Diego, *Seattle,* and Los Angeles.

- **Concurrent HOV Flow Lane**. A freeway lane in the peak direction of travel, not physically separated from the general-purpose traffic lanes, designated for the exclusive use by HOVs for all or a portion of the day. Concurrent flow lanes are usually, although not always, located on the inside lane or shoulder. Paint striping is a common means used to delineate these lanes. HOV facilities of this type are usually open to buses, vanpools, and carpools. This is the most common type of HOV lane, with projects in operation in Seattle, the San Francisco Bay Area, Los Angeles and Orange County, Denver, Salt Lake City, Phoenix, Dallas, Houston, Minneapolis, Atlanta, Miami and Ft. Lauderdale, Orlando, Virginia, Maryland, Nashville, Memphis, New York/New Jersey, and other areas.

Exclusive – US 290, Houston, TX

Concurrent Flow – I-405 Orange County, CA

Busway – East Transitway, Ottawa

Contraflow – I-30, Dallas, TX

Figure 3. Categories of HOV Facilities.

- **Contraflow HOV Lane**. A freeway lane in the off-peak direction of travel, commonly the inside lane, designated for exclusive use by HOVs traveling in the peak direction. The lane is typically separated from the off-peak direction general-purpose travel lanes by some type of changeable treatment, such as plastic posts or pylons that can be inserted into holes drilled in the pavement, or a moveable barrier. Contraflow lanes are usually operated during the peak periods only; many operate only during the A.M. peak period and then revert back to normal use in non-peak periods. Contraflow HOV lanes may be open to buses-only, buses and vanpools-only, or may also allow carpools. Examples of this type of facility include the approach to the Lincoln Tunnel on Route 495, the Long Island Expressway, and the Gowanus Expressway; all of these are located in the New York/New Jersey area. A moveable barrier is used to create a contraflow lane on the I-30 (East R.L. Thornton) Freeway in Dallas and the Southeast Expressway in Boston.

Many of the initial HOV lanes were bus-only applications or allowed buses and vanpools. In an effort to maximize use, carpools became the dominant use group on most projects during the 1970s and 1980s. The vehicle-occupancy requirements for carpools have evolved over time. A three-person per vehicle (3+) occupancy level was initially used on many projects, but most current facilities use a two-person per vehicle (2+) carpool designation.

- ***High-Occupancy Toll (HOT) Lanes and Value Pricing**.* More recently, value pricing projects including high-occupancy toll (HOT) lanes, have been implemented. These approaches are part of a broader managed lanes concept that employs market forces to help maximize use of the facilities. Value pricing and HOT lanes allow single-occupant or lower occupancy vehicles to use an HOV lane for a fee, while maintaining free travel to qualifying HOVs. The I-15 FasTrack™ Express Lanes in San Diego allow single-occupant vehicles to use the HOV lanes for a fee, while the QuickRide program on the I-10 West and US 290 HOV lanes in Houston allows access by 2+ carpools for a fee during the 3+ restricted period.

Bus-only and HOV lanes are also in operation on arterial and city streets in many areas. These facilities provide additional travel time savings and trip time reliability to buses and HOVs in congested urban areas. The following types of arterial street HOV lanes are currently in operation in large, medium, and small urban areas throughout the country.

- *Bus Malls*
- *Bus-only Lanes*
- *HOV Lanes*

These facilities may use the curb lane, the right side travel lane, the left side travel lane on a one-way street, or a contraflow lane. While the information presented in this handbook is appropriate for use with arterial street HOV lanes, these types of facilities are not specifically addressed.

The remainder of this chapter will highlight the key topics addressed in Chapters Three through *Eight*.

Chapter Three – Background and Planning for Operations

I. *Chapter-At-a-Glance*

This chapter presents the background to operating HOV facilities. The term planning for operations is used to identify the activities that should be conducted prior to opening a transportation facility and that are intended to assist in making decisions relating to the operation of a project. A number of elements should be in place prior to operating an HOV lane. These elements include the goals, objectives, and measures of effectiveness (MOE) to be used for assessing the performance of an HOV lane, an operations plan, a performance monitoring and evaluation plan, and an operations management team. *The following sections are included in this chapter.*

II – Goals, Objectives, Performance Measures, and Evaluation Program.
This section describes the development and application of goals, objectives, and performance measures with HOV facilities. It also describes the key elements associated with monitoring and evaluating HOV facilities.

III – Agencies Involved in Operating HOV Facilities
This section highlights the agencies typically involved in operating HOV facilities. The roles and responsibilities of the various agencies are summarized and the benefits of ongoing coordination and cooperation are discussed.

IV – Elements on HOV Operation and Enforcement Plan
This section presents the elements commonly found in an HOV operations and enforcement plan. These elements include the type and design of an HOV facility, the vehicles allowed to use the facility, the vehicle-occupancy requirement, the type and orientation of transit services provided, the hours of operation, enforcement techniques and strategies, incident management techniques, and special operating considerations.

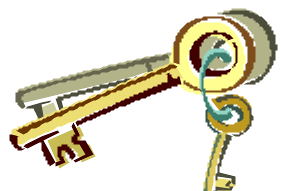
II. Goals, Objectives, Performance Measures, and Evaluation Program

Assessing potential changes in HOV vehicle requirements and operating hours should be based on the goals, objectives, and performance measures established for the project. The HOV Performance Monitoring, Evaluation, and Reporting Handbook provides a comprehensive guide to HOV system goals, objectives, measures of effectiveness (MOEs), and monitoring the performance of HOV facilities. This section will highlight the key elements associated with using the goals, objectives, and MOEs to guide the assessment of potential changes in operating HOV facilities.

III. Agencies Involved in Operating HOV Facilities

Similar to the planning phase for an HOV facility, numerous agencies and groups are typically involved in developing an operations plan for a project and in the ongoing operation of an HOV facility. The participation of the appropriate agencies and individuals is key to ensuring that all groups are involved in discussing the different operational strategies and enforcement techniques, that potential issues are discussed and resolved prior to implementation, and that all groups have a common understanding of the project.

Involvement of All Appropriate Agencies

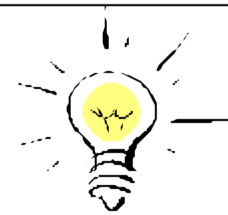


A key to the successful operation of HOV facilities is to involve staff from all appropriate agencies and groups in the development of the operations and enforcement plan and in the ongoing monitoring of the project. Involving these individuals in discussions of possible changes in operations is also important.

One approach used in many areas is to continue the multi-agency team formed during the planning phase of a project through the development of the operations plan, and throughout the operation of a facility. A special subgroup or committee, comprised of the operation and enforcement personnel from various agencies, may be formed to ensure that the individuals responsible for operating and enforcing the facility are involved in developing the plan and in ongoing proactive management of the facility.

Table 1 identifies the various agencies and groups that should be included in the ongoing operation of an HOV facility. The roles and responsibilities of each group are highlighted in the table and described in more detail below. Transportation professionals can use the information in Table 1 as a guide to help ensure that consideration has been given to including the appropriate agencies in the operation of an HOV facility and in any decisions to change operations. The exact approach, as well as the agencies and individuals to involve, will vary by project and by area.

Multi-Agency Teams



Multi-agency teams or committees have been used in many areas to help coordinate planning, designing, funding, implementing, operating, marketing, and evaluating HOV facilities. A special subgroup, comprised of the operation and enforcement personnel for various agencies, may be formed to focus on the operation of an HOV lane. These multi-agency terms help ensure that all appropriate agencies are involved in operating HOV projects, considering possible issues and opportunities, and assessing possible changes.

State Department of Transportation. The state department of transportation or the state highway department is usually the lead agency with HOV facilities on freeways. These agencies have overall responsibility for HOV lanes, including developing the operation and enforcement plan, operating the facility, performance monitoring, and assessing potential changes in operations. In many areas, state departments of transportation have been responsible for organizing, staffing, and chairing the multi-agency project management team associated with HOV facilities. Representatives from a variety of departments within the agency may participate. These might include the planning, design, marketing or public information, construction, legal, operation, traffic management, ITS, and highway assistance departments.

Transit Agencies. Transit agencies usually have the lead responsibilities with HOV facilities on separate rights-of-way. In other cases, the transit agency may be a co-sponsor or a supporting agency. If the transit agency has the overall responsibility for the project, they will also have the lead role in developing an operations plan, operating the facility, performance monitoring, and assessing possible changes. On freeway HOV lanes, a transit agency typically plays a supporting role. Key responsibilities may focus on the bus operations, rideshare services, and overall project coordination. Ensuring bus operations are not degraded or compromised by other user groups is often a key concern of transit agencies.

State and Local Police. The involvement of enforcement personnel throughout all aspects of planning, designing, constructing, implementing, and operating HOV facilities was stressed earlier in this Manual. Experience indicates that including state, local, and transit police in the development of the operation and enforcement plan is critical to the success of an HOV project. Ensuring that the needs of enforcement personnel are considered early in the planning process is important to developing a facility that can be enforced. Enforcement personnel may take a lead role in the development of the enforcement section of the plan.

Table 1. Agencies and Groups Involved in Operating Facilities.

Agency or Group	Potential Roles and Responsibility – Operations
State Department of Transportation	• Overall project management. • Lead in developing operation and enforcement plan. • Operating facility. • Performance monitoring. • Assessing potential operating changes. • Staffing multi-agency team or committee.
Transit Agency	• Supporting role or overall project management on bus-only projects. • Assisting with operation and enforcement plan. • Bus operations. • Performance monitoring - bus • Assisting with enforcement.
State Police	• Assist with development of operation and enforcement plan. • Responsible for enforcement of freeway HOV facilities. • Coordination with judicial personnel.
Local Police	• Assist with development of operation and enforcement plan. • May assist with enforcement. • Coordination with judicial personnel.
Local Municipalities (cities/counties)	• Support role with freeway HOV facilities. • May have overall project management with arterial street and traffic signal applications. • Developing or assisting with operation and enforcement plan. • Operate arterial street HOV lanes. • Staffing multi-agency team or participating on team.
Rideshare Agency	• Assist with development of operation and enforcement plan. • Performance monitoring – rideshare. • Participate on multi-agency team.
Transportation Management Center	• Often operated by state departments of transportation. • Assist in developing operating plan. • Provide daily management of freeway and HOV systems. • Performance monitoring. • Participate in multi-agency team.
Metropolitan Planning Organization (MPO)	• Assist in facilitating meetings and multi-agency coordination. • Ensure that projects are included in necessary planning and programming documents. • May have policies relating to HOV facilities.
Federal Agencies—FHWA and FTA	• Funding support. • Overall approval of various steps.
Other Groups	• Judicial system—state and local courts. • EMS, fire, and other emergency personnel. • Tow truck operations. • Traffic information service providers. • State legislatures and policy makers.

Local Municipalities. City or County departments may have important supporting roles on HOV facilities on freeways and in separate rights-of-way. On projects headed by the state or transit agency, local jurisdictions are likely to play a supporting and coordinating role in the operating of HOV lanes. *Involving local municipalities is especially important if there are freeway HOV bypass entrance or exit ramps. For example, the City of Seattle supports and provides enforcement for two HOV-only ramps that bring traffic into and out of downtown Seattle and the I-5 reversible center roadway.*

Metropolitan Planning Organization (MPO). Representatives from the MPO are usually members of multi-agency groups associated with HOV facilities. The MPO may have policies relating to various aspects associated in the operation and enforcement of an HOV facility. Staff from the MPO may help facilitate meetings, assist with multi-agency coordination, and assess possible changes in operating policies.

Rideshare Agency. In most metropolitan areas, the transit agency operates not only the bus service but also provides ride matching services, vanpool programs, and other ridesharing services. In some areas, however, these activities are the responsibility of a separate agency or organization. In these cases, the rideshare agency is included as a member of the multi-agency operations team.

Transportation Management Center. Most major metropolitan areas have transportation management centers (TMC). The centers use ITS and other advanced technologies to proactively manage the freeway system, including HOV lanes. Although a variety of institutional approaches are used with transportation management centers, all have a common focus on multi-agency cooperation and communication. In many cases, the state department of transportation is the lead agency in the development and operation of TMCs. Staff from a TMC should be active members of an HOV operations team.

Federal Agencies. Representatives from FHWA and FTA may be involved in assessments of potential changes in HOV operations. Representatives from FHWA and FTA often participate on the multi-agency team.

Other Groups. Other groups may be members of the operations team. These groups may include representatives from the state and local judicial system responsible for enforcing fines and citations; EMS, fire, and other emergency personnel responsible for responding to incidents and accidents on the facility; and tow truck operators who may be responsible for removing disabled vehicles. In addition, traffic and transportation information service providers may be included in the operations team. Representatives from these public and private entities may have roles in both obtaining information on the operation of an HOV facility and in disseminating information to the public. In addition to the agencies and groups listed previously, policy makers at the national, state, and local levels may influence operating decisions related to HOV facilities. For example, based on the

Transportation Equity Act for the 21st Century (TEA-21), states were authorized to allow Inherently Low Emission Vehicles (ILEVs) to use HOV lanes without meeting occupancy requirements based on the passage of enabling legislation. State legislatures may also set policies relating to fines and other operating elements.

IV. Elements of an HOV Operation and Enforcement Plan

This section highlights the elements commonly found in an HOV operation and enforcement plan. These elements relate to the type and design of a project, the vehicles allowed to use the facility, the vehicle-occupancy requirement, the type and orientation of the transit services provided, the hours of operation, enforcement techniques and strategies, incident management techniques, and special operating considerations. These elements are discussed briefly in this section. The vehicle requirements, vehicle-occupancy levels, and operating hours are discussed in more detail in the next chapters.

HOV Operational Alternatives. *The type of HOV facilities will influence t*he *operation and enforcement alternatives available for consideration*. For example, the operating strategies *associated with* reversible or contraflow HOV lanes will be different than those used with concurrent flow lanes. The enforcement requirements and techniques will also vary based on the *type* of HOV facility. *A barrier-separated HOV lane provides different enforcement approaches than a concurrent flow HOV lane.*

Ingress and Egress. The nature and number of access points will also influence the operation of an HOV facility. Access considerations are closely linked to the type of HOV facility being considered. Some access treatments are more appropriate with certain kinds of HOV lanes, while others may be realistic only with specific types of facilities.

Vehicle Eligibility and Vehicle-Occupancy Requirements. The types of vehicles allowed to use an HOV facility and the number of people required in a vehicle will influence the operation of a project. Issues to be considered in determining the appropriate vehicle mix and occupancy requirement include safety, demand, project objectives, and special features. Public perceptions related to use levels may also be considered.

Transit Facilities and Services. The nature and orientation of transit services using an HOV facility, as well as the supporting features, will impact operations. For example, a facility with high volumes of buses may require a different operational approach than one oriented toward carpools.

Hours of Operation. As noted previously, there is a strong relationship between operation and enforcement. The operation and enforcement plan should identify the anticipated hours the HOV facility will be open for use. HOV facilities may be operated on a 24-hour basis, during major portions of the day, or only during the peak-periods. If a lane is not operated for HOVs on a 24-hour basis, how the facility will be used during non-HOV operating periods must be defined. Options may include allowing general-purpose traffic to use the facility or closing the lane. The type and orientation of the HOV facility will influence the hours of operation.

Enforcement. A major element of the operation plan and ongoing operations should focus on the enforcement strategies to be used on the facility. Elements that should be addressed include the enforcement techniques, design features, violation penalties and fines, and roles and responsibilities of the various *law enforcement* agencies. The enforcement elements should include communication and coordination with representatives from the state and local judicial systems to ensure that citations will be upheld in court.

***Voluntary Enforcement**. In addition to the legal enforcement conducted by police agencies and state patrols, some areas have voluntary enforcement educational efforts. These ongoing educational programs are needed as people move into an area from places that do not have HOV lanes. Brochures and websites are two examples of ongoing educational approaches. The Seattle area operates a HERO program where citizens can voluntarily phone 206-764-HERO and report violators observed in the HOV lanes. The motorists receive an educational brochure in the mail that explains the HOV lane rules and regulations. Only a small percentage of reported violators are repeat offenders, so the educational effort appears to be worthwhile. Information on vehicles reported violating the HOV requirements at the same location and time over a multiple month period, is passed on to law enforcement personnel. Concerns about "big brother" are addressed by specifically mentioning that only law enforcement personnel can write a ticket.*

Incident Management. The incident management portion of an operation and enforcement plan usually focuses on two major components. The first outlines the procedures and techniques that will be used to respond to incidents and accidents on the HOV facility. The second element addresses whether or not the HOV lane will be used to help manage incidents and accidents on the freeway-general purpose lanes, and if so, the procedures and techniques that will be used on these instances. Coordination with TMC, EMS, and other emergency personnel is a key element of incident management.

Special Operational Considerations. Depending on the type of HOV facility, the objectives of the project, and the local situation, there may be other special considerations relating to value pricing, low-emission vehicles, and truck use.

Chapter Four – Assessing Vehicle Eligibility Requirements

This chapter reviews the types of vehicles usually considered for use of an HOV facility. The advantages of allowing different vehicles are highlighted along with some of the issues associated with various approaches. Techniques for assessing the potential demand associated with different vehicle requirements are presented.

I. Vehicle Eligibility Requirements

Vehicle eligibility requirements identify the types of vehicles allowed to use an HOV lane. Determining vehicle eligibility is important, as it influences other decisions relating to the operations of the facility. The following types of vehicles may be using an HOV lane or may be considered for use of an HOV facility.

Vehicles Meeting Occupancy Requirements

- Buses *carrying passengers.*
- Vans, vanpools, and shuttle (airport, taxi, etc.) meeting eligibility requirements.
- Carpools in automobiles and light trucks meeting eligibility requirements.

Vehicles Not Meeting Occupancy Requirements

- *Designated public transportation vehicles with only the driver (deadheading).*
- Motorcycles.
- Marked law enforcement and emergency vehicles.
- Stickered vehicles.
- Value pricing and tolled vehicles (high-occupancy toll (HOT) projects).
- Low-emission and energy-efficient vehicles.

Vehicles Not Usually Allowed

- Commercial vehicles and trucks

The general characteristics of these vehicles are described next. The advantages, disadvantages, and potential issues associated with allowing each type of vehicle to use an HOV facility are presented in Table 2 and summarized in this section.

Table 2. Vehicle Eligibility Considerations.

Vehicle Type	Advantages	Disadvantages
Vehicles Meeting Occupancy Requirement		
Buses	• Highest person-moving capacity. • Greatest potential for increasing corridor throughput.	• Unless there are high numbers of buses, the lane will look unused.
Vans, Vanpools, and Shuttles Meeting Occupancy	• High person-moving capacity.	• Unless there are high numbers of vanpools, the lane will look unused, creating an empty lane syndrome.
Carpools using automobiles and pickup trucks	• Adds users at no public cost. • Adds to person-moving efficiency. • Helps avoid having lane look empty.	• Too many carpools may create congestion in the HOV lane, reducing travel time savings and travel time reliability. • May be safety concerns with some facilities. • Equity issue when HOV requirements exceed the capacity of small automobiles (e.g. 2-seater sports cars).
Vehicles Not Meeting Occupancy Requirement		
Designated Public Transportation Vehicles with Only Driver	• *Enhance bus operation efficiencies.*	• *Potential public perception problems if only operator.*
Marked law enforcement and emergency vehicles	• Travel time savings and enhanced reliability to emergency vehicles.	• Potential public perception problems if only operator.
Motorcycles	• Adds vehicles in lanes.	• Potential safety concerns. • Possible public perception problems of single-occupant vehicle.
Stickered vehicles	• Maximize available capacity. • Manage demand. • Expand eligible user group. • Address actual or perceived low use.	• Makes enforcement more difficult. • Time and cost to administer program. • Possible confusion among users. • May add too many vehicles to the facility.

Table 2. Vehicle Eligibility Considerations - Cont.		
Vehicle Type	Advantages	Disadvantages
Value pricing and tolled vehicle	• Maximize available capacity. • Manage demand. • Expand eligible user group. • Address actual or perceived low use. • Generate new revenues.	• Makes enforcement more difficult. • Time and cost to administer program. • Possible confusion among users. • May add too many vehicles to the facility. • Cost of automated toll equipment. • Public and policy maker concerns related to equity, double taxation, and use of revenues.
Low-emission and energy-efficient vehicles	• May encourage purchase and use of low-emission and energy-efficient vehicles. • Adds vehicles to HOV lane.	• Potential public perception problems if vehicles do not meet the occupancy requirements. • Potential to make enforcement more difficult. • May cause congestion on the facility if too many low-emission and energy-efficient vehicles with only the driver. • *May be confusion among buyers, automobile dealers, and policy makers on which vehicles qualify.*
Vehicles Not Usually Allowed		
Commercial vehicles and heavy trucks	• Exclusive use of HOV lanes during off-peak hours by trucks may help reduce truck traffic in freeway lanes. • Enhances good movement and economic development.	• Potential safety concerns if trucks mixed with HOVs. • Safety concerns during transition period. • Access points may not serve commercial origins and destinations. • Geometric restrictions may not accommodate trucks. • Does not provide incentive to use transit or rideshare. • Does not enhance people moving capability.

Buses. Buses are usually given first consideration in the use of an HOV facility. High volumes of buses offer the greatest potential benefit for increasing the people carrying capacity of a facility, as well as energy savings and air pollution reductions. Buses may be the only vehicles allowed to use a facility or buses may be one of many eligible users. Examples of the former include the busways in Ottawa, Pittsburgh, and Minneapolis-St. Paul; the contraflow HOV lane on Route 495 approaching the Lincoln Tunnel in New York City; and the bus-only shoulder freeway lanes on Highway 99 in Vancouver and freeway sections in the Minneapolis-St. Paul area. The bus-only facilities in Ottawa, Pittsburgh, Miami, and Minneapolis-St. Paul are all located in separate rights-of-way. These facilities provide high quality service to large numbers of buses. The other facilities are restricted to buses-only due to safety concerns or the desire to provide priority treatments for buses around specific freeway bottlenecks. Bus Rapid Transit (BRT) are being planned, implemented, and operated in some areas. Although buses provide the greatest person carrying capacity, corridors in many metropolitan areas in North America do not have high enough current or projected transit vehicle volumes to warrant limiting the use of a facility to buses only. Thus, most HOV lanes allow other vehicles meeting the vehicle occupancy requirement along with buses. Deadheading buses refers to the operation of buses in non-revenue service. Deadheading usually occurs in the morning and evening as buses are going to and from the garage to the start or the end of a route. Deadheading also occurs with express services, as buses travel back out to start another trip. Operating efficiencies may be realized by allowing deadheading buses to use the HOV lanes. For example, allowing deadheading buses to use an HOV facility may reduce transit operating costs or increase revenue service at no additional operating cost. Buses with only an operator in an HOV lane may create public perception problems, however.

Vans and Vanpools. The next vehicles often considered for HOV lane use are vanpools. Although vans have operating characteristics similar to automobiles, vanpools have higher vehicle-occupancy levels than carpools. As a result, vanpools may be given preference over carpools in some situations. Vanpools are currently authorized to use all of the non-bus only HOV facilities in North America. Some metropolitan areas have active company-based and area-wide vanpool programs that help support the formation and ongoing operation of vanpools.

Carpools Using Automobiles and Pickup Trucks. Carpools comprise the majority of vehicles on most HOV lanes. Carpools add to use levels at no additional public cost and can enhance the person carrying capacity of a facility. A potential disadvantage of allowing carpools in an HOV lane is that congestion may be created by too many vehicles, which may negatively impact the travel time savings and travel time reliability of buses. As discussed in Chapter Five, different carpool occupancy requirements may be used to influence demand.

Marked Law Enforcement and Emergency Vehicles. Marked law enforcement and emergency vehicles are typically allowed to use all HOV facilities, even when not on an emergency trip. In most cases, marked law enforcement emergency vehicles do not make extensive use of HOV lanes due to access limitations, hours of operation, *public perception,* and other factors. Use of the HOV lanes in

Northern Virginia by law enforcement and emergency personnel traveling in their own vehicles without meeting the occupancy requirements has been reported as a significant problem.

Motorcycles. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 authorized the motorcycle use of HOV facilities, regardless of the number of riders. Previous federal regulations provided some flexibility for states and other operating agencies in determining motorcycle use of HOV lanes based on safety concerns.

Stickered Vehicles. One possible approach to managing demand on an HOV facility is through the use of a sticker program. The basic concept of this technique is to allow vehicles with a valid sticker or electronic device like an automated vehicle identification (AVI) tag to use an HOV facility. This approach was used for a time on the Southeast Expressway contraflow HOV lane in Boston. A 3+ vehicle-occupancy requirement is in use on this facility, but 2 person carpools with a valid sticker were allowed to access the lane. The stickers were distributed by the Massachusetts Highway Department (MassHighways), which is responsible for the project. To ensure that the HOV lane does not become too congested, the stickers were color coded to help regulate use. Vehicles with license plates ending in an odd number had blue stickers and were allowed in the lane on odd numbered days. Vehicles with license plates ending in even numbers had red stickers and were able to access the lane on even numbered days. Potential advantages of this approach include maximizing available capacity in the HOV lane, managing demand, expanding the eligible user groups, and addressing actual or perceived perceptions of low use. Potential disadvantages include making enforcement more difficult, adding extra administrative functions and costs to manage the program, confusing users, and adding too many vehicles to the lane.

Value Pricing and Tolled Vehicles. Another possible approach is to allow lower or single-occupant vehicles to use an HOV facility for a fee. This technique, which may be referred to as priority pricing, value pricing, or high-occupancy toll (HOT) lanes, is currently in use on the I-15 HOV facility in San Diego and the I-10 West and U.S. 290 HOV lanes in Houston. It is being considered and implemented in other areas. Potential advantages of this technique include maximizing available capacity, managing demand, expanding the eligible user groups, addressing real or perceived low use levels, and generating new revenues. This approach may also provide opportunities for new public/private partnerships or other innovative methods. Possible disadvantages include making enforcement more difficult, adding costs to administer the program, adding costs associated with automated toll collection, confusing users, and adding too many vehicles to the lane. This approach may also raise concerns from the public and policy-makers relating to equity, double taxation, and use of revenues.

Low-Emission and Energy-Efficient Vehicles. The Clean Air Act Amendments of 1990 and TEA-21 allow states to exempt Inherently Low-Emission Vehicles

(ILEVs) from HOV occupancy requirements. Currently, 10 states have approved legislation allowing ILEVs to use HOV lanes. Energy-efficient vehicles, such as hybrids, are not included in the TEA-21 definition of exempt vehicles or the initial legislation approved in the 10 states noted above. Four states—Arizona, California, Colorado, and Georgia—approved subsequent legislation allowing hybrids to use HOV facilities without meeting occupancy requirements if authorized in federal legislation or federal agency action. Virginia is the only state currently allowing hybrids to use the HOV lanes. FHWA has communicated to Virginia officials that it will not act on the state's request while the reauthorization process is underway.

Commercial Vehicles. Commercial vehicles or semi-trucks are not allowed to use any HOV facility in North America, regardless of the number of passengers. This restriction has been applied for safety reasons and because allowing trucks would not encourage ridesharing or reduce VMT. Potential concerns with opening HOV facilities to commercial vehicles during peak and off-peak periods include lack of compatibility with policies and objectives to increase ridesharing and vehicle occupancy levels, lack of access points to meet the origins and destinations of trucks, design limitations which may not accommodate truck movements, and conflicts between commercial vehicles and HOVs.

II. Issues to Consider in Changing Vehicle Eligibility Requirements

A number of factors should be considered in assessing possible changes in vehicle requirements for an HOV facility. The exact factors and threshold levels will vary by metropolitan area depending on local goals and objectives, facility types, design treatments, system connectivity issues, and local conditions. The elements discussed in this section can be used to help develop guide consideration of changes in vehicle requirements on HOV facilities.

- Metropolitan and Project Goals and Objectives
- Type of HOV Facility
- Supporting Facilities and Services
- Specific Design or Operating Limitations
- Segment and Areawide Continuity

Metropolitan and Project Goals and Objectives. The goals and objectives of a specific HOV project or an HOV system should be used in considering possible changes to vehicle requirements. For example, the goals and objectives for an HOV ramp meter bypass, a bus-only facility on a separate right-of-way, and a concurrent flow HOV lane serving primarily carpools, may be different.

Type of HOV facility. The type of HOV facility may influence the potential vehicle requirements.

Supporting Facilities and Services. The type and levels of support facilities and services may influence consideration of changes to HOV facilities.

Specific Design and Operating Limitations. Consideration of changes in vehicle criteria may be influenced by design or operating constraints associated with a specific facility. For example, facilities with specific design or operating limitations may be restricted to buses, or to buses and vanpools.

Segment and Areawide Area Continuity. If there is more than one HOV facility in operation or in the planning stage in a metropolitan area, consideration of changes on one facility may influence the operation of other HOV lanes. Consideration should be given to uniform vehicle requirements. Maintaining the same requirements on multiple facilities can improve public understanding and simplify enforcement. This approach may not be appropriate if there are different types of HOV facilities in an area or if significantly different travel and mode share characteristics exist in various corridors. Several metropolitan areas use different vehicle requirements on HOV facilities, while other areas use the same regulations on all HOV lanes.

Issues to Consider with Value Pricing

Based on the limited experience with these projects, it appears a number of issues should be examined when pricing strategies are being considered on a new or an existing HOV lane. As described next, these issues include the project objectives, target markets, pricing alternatives, potential impact on HOVs, use of revenues, public and policy maker perceptions, and operational approaches.

Project Objectives. Pricing or sticker programs may be considered for a number of reasons. Determining the specific goals and objectives of a project is a critical first step. Possible objectives for a pricing project include improving HOV lane utilization or maximizing available capacity by allowing lower occupancy vehicles, restoring free flow to HOV lanes by charging lower occupancy vehicles, generating additional revenues, introducing another travel option, and supporting other secondary impacts such as air quality.

Target Markets. The potential market or markets being considered for the pricing project should be examined. Possible target markets include drivers of lower-occupant vehicles and single-occupant vehicles. For example, the I-15 project in San Diego is allowing single-occupant vehicles to use the HOV lane for a fee, while the demonstration on the I-10 West HOV lane in Houston will allow 2 person carpools to pay for use of the lane during the period currently restricted to 3+ carpools. The Route 91 Express lanes in Orange County, California use a different approach. As a for-profit toll facility, all vehicles are expected to pay a fee, although the pricing goal is adjusted to favor the formation of 3+ HOVs.

Pricing Alternatives. Examining the amount the target market may be willing to pay to use an HOV lane should also be considered. A number of factors may be included in this assessment. One of the major elements that will need to be examined is the estimated demand at various pricing levels and quality of service. In addition to the traditional cost-to-demand relationship, other factors to consider include the bus fares in the corridor and the cost of other transit alternatives.

Impact on Existing or Projected HOV Lane Users. The impact on existing or projected HOV lane users from a pricing strategy will also need to be considered. Ideally, there should be no impact on current HOV users. The impact on the general-purpose lanes should also be considered. A number of negative impacts might result from pricing, however. For example, increased congestion in the HOV lane might occur if tolls are set too low or if too many stickers are distributed, resulting in too many lower or single-occupant vehicles using the facility. This situation could result in slower travel speeds, reduced travel time savings, and lower levels of travel time reliability. Current HOV volumes may decline if existing bus riders, carpoolers, and vanpoolers decide to change to driving alone for a fee. On the other hand, if revenues generated from the project are used to enhance bus service in the corridor, to reduce bus fares, or to make other improvements benefiting HOVs, bus ridership, and carpool and vanpool use may increase.

Level and Use of Revenues. The level of revenues generated and the use of the revenues should also be considered. The funds generated by the pricing project and the cost to operate and administer the program should be carefully examined, along with how any excess revenues will be spent. The focus groups conducted during the planning process for the Houston I-10 West demonstration, as well as findings from other congestion pricing studies around the country, indicate that public reaction to a possible project is influenced by how the revenues are anticipated to be used. Public support appears to be higher if the revenues are used for transit and transportation improvements, than if they are used for other purposes. The revenues for the I-15 project in San Diego are funding additional transit services in the corridor. If the HOT lane is part of a toll or managed lane project, the funding and revenue agreements among the toll operator and any participating public agency will need to be determined. The tolls may be used to help fund the project.

Public Reaction. The reaction of the public toward a pricing project should be considered. Motorists and current HOV users may have a negative reaction to the concept of pricing, since freeways and roadways have already been paid for through tax dollars. In addition, equity issues or concerns that only the rich will be able to afford to use the lanes may be an issue. Experience with existing projects indicates that all income levels use value-priced lanes.

Operational Strategies. A number of operational strategies can be used with pricing projects. The two general types of approaches are a manual or static technique and the use of real-time pricing based on congestion. The use of electronic toll collection (ETC) allows for real-time pricing.

Issues to consider in allowing other types of vehicles (low-emission, energy-efficient, etc.) will also be highlighted in this section.

III. Techniques for Assessing Changes in Vehicle Eligibility Requirements

This section will present techniques for assessing changes in vehicle requirements. Different methods will be highlighted for different types of vehicles (pricing, low-emission, energy-efficient) etc. The approaches will all focus on assessing the potential impact on the HOV facility.

Vehicle Volumes. One criteria that can be used to assess the impact of changes in vehicle requirements is the number of vehicles using the facility. *The maximum number of vehicles per lane per hour for a specific HOV facility should be identified. This maximum number represents the point at which the lanes are anticipated to become too congested.*

Vehicle Speeds. The speed of vehicles traveling in an HOV lane can be used as another criteria to help assess changes in vehicle requirements. The impact of vehicle speeds in the HOV lane on non-HOV speeds and congestion may also need to be considered. The desired operating speed for a facility should first be identified based on the speed limit for the facility, the general travel speeds in the corridor or freeway, and any special design and operating characteristics.

Travel Time Savings. This criteria relates to both vehicle volumes and travel speeds in the general-purpose lanes, as well as those on the HOV facility. Providing travel time savings to HOVs is critical to the ongoing success of a project. It is possible, however, for travel speeds to decrease slightly on a HOV lane, while still maintaining significant travel time savings over the general-purpose lanes. A desired travel time advantage for HOVs should be established and possible changes can be examined.

Travel Time Reliability. Surveys of carpoolers, vanpoolers, and bus riders indicate that the travel time reliability provided by HOV facilities is as important as the travel time savings in the decision to change from driving alone to using an HOV. Thus, one measure for consideration in assessing changes in vehicle requirements is the travel time reliability provided by an HOV facility.

Chapter Five – Assessing Vehicle-Occupancy Requirements

This chapter provides an overview of possible vehicle-occupancy requirements and techniques to assess potential changes in vehicle-occupancy requirements.

I. Possible Vehicle-Occupancy Requirements

If carpools are allowed to use an HOV facility, the vehicle-occupancy requirement must be established. The planning process for an HOV lane typically includes an analysis of the demand for a facility at different vehicle-occupancy levels and the impact these requirements will have on traffic flow. The goal is to set the occupancy requirement at a level that will encourage the use of carpooling, vanpooling, and taking the bus, but will not create too much demand to make the lane congested.

During the late 1970s and early 1980s, FHWA used a 3+ definition for carpools on HOV projects funded through federal programs. As a result, HOV projects opened during that time period, including the Shirley Highway HOV lanes in northern Virginia and the El Monte busway on the San Bernardino Freeway in Los Angeles, used a 3+ vehicle occupancy requirement. The 3+ requirement has been in effect over the life of the Shirley Highway HOV lanes. The 3+ requirement was in use on the El Monte busway from 1974 to 2000 when the state legislature approved legislation lowering the occupancy requirement to 2+. Due to the congestion, slower travel times, and reduced trip time reliability experienced by HOV lane users with this change, legislation was approved increasing the occupancy requirement back to 3+ during the morning and afternoon peak-periods.

Changes in vehicle-occupancy levels may be needed over the life of an HOV facility. For example, some HOV lanes using a 2+ requirement have experienced congestion resulting in reductions in trip time reliability and slower travel times. This situation happened on both the I-10 West and U.S. 290 HOV lanes in Houston. *To address this problem, the vehicle occupancy requirements were increased to 3+ during the morning and afternoon peak hours. Increasing vehicle occupancy levels is* not *an* easy *change* to make. Political pressure may prevent increasing occupancy levels. Issues related to system wide compatibility also need to be considered.

Currently, the majority of operating HOV facilities uses a 2+ vehicle-occupancy requirement. A 3+ occupancy requirements is in use on a few facilities. Three projects—the El Monte Busway on the San Bernardino Freeway in Los Angeles and the I-10 West and U.S. 290 HOV lanes in Houston—use a 3+ occupancy requirement during the morning and afternoon peak hours and a 2+ requirement at other times. Although no HOV facility currently requires four or more (4+) occupants, this level has been used in the past. The characteristics, advantages, and disadvantages of the various vehicle-occupancy requirements are briefly described in this section and highlighted in Table 3.

Table 3. Vehicle-Occupancy Requirement Criterion.

Vehicle-Occupant Level	Advantages	Disadvantages
Two or more (2+) persons per vehicle	• Easiest level of carpools to form. • Often significant numbers of existing 2+ carpools in a corridor.	• May be too many 2+ carpools resulting in congestion in an HOV lane. • May not provide incentive to carpool if high number of existing 2+ carpools or help reduce vehicle trips.
Three or more (3+) persons per vehicle	• Can address congestion problems at the 2+ level. • Higher person moving capacity.	• Harder for individuals to form 3+ carpools. • May not have enough 3+ carpools to make lane look used, causing the empty lane syndrome. • If existing carpools cannot find an additional passenger, they may travel in the general-purpose lanes; adding to the congestion in these lanes.
Four or more (4+) persons per vehicle	• Can address congestion problems at the 3+ level. • Higher person moving capacity.	• Hard for individuals to form 4 person carpools. • Harder to operate on a regular basis due to individual travel needs and schedules. • May not have enough 4+ carpools to make lane look used, causing the empty lane syndrome. • If existing carpools cannot find an additional passenger, they may travel in the general-purpose lanes; adding to the congestion in these lanes.
Variable requirements by time of day (3+ peak hours, 2+ other operating hours)	• Can address congestion problems during peak-periods.	• May be confusing for users, especially during transition periods. • May make enforcement more difficult, especially during transition periods.

Two or More (2+) Persons per Vehicle. Two or more persons (2+) per vehicle represent the lowest level of carpooling. Forming a two person carpool is much easier than forming a three or four person carpool. Many two person carpools are comprised of family members, co-workers, or friends. *While infants and children qualify as the second person, a pregnant woman does not qualify as two.* Corridors may have significant numbers of existing 2-person carpools, providing a target market for an HOV facility. On the other hand, if the number of 2+ carpools in the corridor is already relatively high, such as 30 percent on a 4-lane facility, this designation may not improve the person movement capacity of a facility. Implementation of 2+ eligibility level may also represent a staged commitment to ridesharing. If an HOV lane becomes too congested at the 2+ occupancy level, the requirement can be increased to 3+. As noted previously, political pressure may prevent increasing occupancy levels.

Three or More (3+) Persons per Vehicle. The next level for defining a carpool is to require three or more persons (3+) per vehicle. Vehicle volumes at the 3+ level are usually lower than at a 2+ requirement, as it is more difficult for individuals to form three person carpools, so some potential carpoolers may not be able to use a facility at a 3+ requirement.

Four or More (4+) Persons per Vehicle. A four or more (4+) persons per vehicle requirement was used during the initial stages of the Shirley Highway HOV lanes in Northern Virginia and the I-10 West HOV lane in Houston. No HOV lane in North America currently uses this occupancy level. It is difficult for most individuals to not only form carpools with four or more persons, but also to operate those that are formed on a regular basis. Most metropolitan areas probably do not have enough demand at the 4+ level to make this a viable option, especially during the early stages of a project.

Variable Vehicle-Occupancy Requirements by Time of Day. Another approach is to change the HOV occupancy requirement by time of day. This technique represents one approach to managing demand on an HOV lane. This approach is used on the El Monte Busway in Los Angeles and the I-10 West and U.S. 290 HOV lanes in Houston. Multi-jurisdictional issues may need to be addressed with this option. This approach can be confusing to users and to enforcement personnel.

II. Techniques to Assess Vehicle-Occupancy Levels

This section will describe techniques for analyzing changes in vehicle-occupancy levels. The general approach for considering changes in vehicle-occupancy levels and factors that may influence vehicle-occupancy requirements are presented. Techniques for analyzing possible changes are presented.

As discussed previously, the goal of an HOV facility is to provide travel time savings and travel time reliability to buses, vanpools, and carpools. The vehicle-occupancy requirement should be maintained at a level that will encourage use of the facility and the formation of new carpools, but that will not create too much demand to make the lane congested.

A number of factors should be considered in assessing the appropriate operating thresholds for an HOV facility. The exact threshold for a specific project will depend on the goals and objectives of the project, the type of facility, the vehicle eligibility and vehicle-occupancy requirements, the level of congestion in the general-purpose lanes, and local conditions and perceptions. For example, the minimum threshold will be lower for a bus-only HOV lane used during the peak hours than for a barrier separated exclusive HOV facility. Table 4 outlines some of the elements practitioners may wish to consider in developing local guidelines for minimum operating thresholds. The general levels that are commonly used throughout the country are highlighted and discussed below.

As noted in Table 4, the type of HOV facility will probably have the most significant influence on the minimum operating threshold. In general, a minimum of at least 400 to 800 vehicles per hour per lane (vphpl) is needed *to carry more people than the general-purpose lanes and to address possible perception issues on the use of the lane* for most HOV facilities. The exceptions to this general guideline are bus-only facilities, HOV bypass lanes, and other special treatments.

While issues may arise if there are not enough vehicles using an HOV facility, problems may also emerge with too many vehicles. Maintaining a level of service in the HOV lane that provides the travel time savings and the travel time reliability bus riders, vanpoolers, and carpoolers have come to expect is important.

Maintaining a desired level of service on an HOV facility should focus on the operating capacity rather than the design capacity. It is generally recognized that volumes of 1,200 to 1,500 vphpl on most types of HOV facilities will begin to experience degradations in travel time savings and travel time reliability. The exact maximum flow will vary by facility, however. Some HOV lanes serving primarily carpools have operated with up to 1,700 or 1,800 vphpl during the peak hour. Others, like the bus-only contraflow lane approaching the Lincoln Tunnel *in New York City,* reach capacity at 700 to 800 vphpl.

The same factors described for the minimum operating thresholds will also influence the maximum operating thresholds. These include the goals and objectives of a project, the type of HOV facility, vehicle eligibility criteria, vehicle-occupancy requirements, the general level of congestion in the corridor, and local conditions. In addition, design considerations may also influence maximum flow levels. These factors are highlighted in Table 5.

Table 4. Elements for Developing Minimum Operating Threshold Guidelines for HOV Facilities.

Possible Elements	Comments/Possible Minimum Thresholds
Goals and Objectives of Project	The goals and objectives of a project may influence the minimum operating thresholds. For example, a project intended to give buses priority around a congested freeway segment could be expected to have a lower threshold than an exclusive HOV lane. Local policies on carpool definitions or other elements may also influence the operating thresholds and should be considered in the development of local guidelines.
Type of HOV Facility	The type of HOV facility will probably have the most influence on the development of local minimum operating guidelines. The following general levels provide an indication of the national experience and can be used in developing local guidelines. Separate right-of-way, bus only—200-400 vphpl Separate right-of-way, HOV—800-1,000 vphpl Freeway, exclusive two-directional—400-800 vphpl Freeway, exclusive reversible—400-800 vphpl Freeway, concurrent flow—400-800 vphpl Freeway, contraflow, bus-only—200-400 vphpl Freeway, contraflow, HOV—400-800 vphpl HOV bypass lanes—100-200 vphpl
Vehicle Eligibility Requirements	Lower minimum vehicle thresholds can be expected, and are usually accepted, with bus-only facilities than with facilities open to buses, vanpools, and carpools.
Vehicle-Occupancy Requirements	Lower minimum vehicle thresholds can be expected with higher vehicle-occupancy requirements.
Level of Congestion Corridor	The minimum vehicle threshold may be higher in a heavily congested corridor than in one with lower levels of congestion. Non-users in heavily congested areas may be much more vocal about a facility they feel is under-utilized than commuters in a corridor where congestion is not at serious levels.
Local Conditions	The perceptions of commuters and the public, as well as any unique local conditions, should be considered in developing minimum operating thresholds. Regional norms are also a factor.

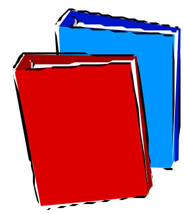
Table 5. Elements for Developing Maximum Operating Threshold Guidelines for HOV Facilities.

Possible Elements	Comments/Possible Maximum Thresholds
Goals and Objectives of Project	The goals and objectives of a project may influence the maximum operating thresholds. For example, a project intended to give buses priority around a congested freeway segment could be expected to have a lower threshold than an exclusive HOV lane. Local policies on carpool definitions or other elements may also influence the operating thresholds and should be considered in the development of local guidelines.
Type of HOV Facility	The type of HOV facility will probably have the most influence on the development of local maximum operating guidelines. The following general levels provide an indication of the national experience and can be used in developing local guidelines. Separate right-of-way, bus only—800-1,000 vphpl Separate right-of-way, HOV—1,500-1,800 vphpl Freeway, exclusive two-directional—1,200-1,500 vphpl Freeway, exclusive reversible—1,500-1,800 vphpl Freeway, concurrent flow—1,200-1,500 vphpl Freeway, contraflow, bus-only—600-800 vphpl Freeway, contraflow, HOV—1,200-1,500 vphpl HOV bypass lanes—300-500 vphpl
Vehicle Eligibility Requirements	Lower maximum thresholds can be expected, and are usually accepted, with bus-only facilities than with facilities open to buses, vanpools, and carpools.
Vehicle-Occupancy Requirements	The vehicle-occupancy requirements will influence use of a facility and the potential for congestion. A higher threshold may be needed with a 2+ requirement.
Level of Congestion Corridor	The maximum operating threshold may be higher in a heavily congested corridor than in one with lower levels of congestion.
Design Considerations	An HOV facility with geometric constraints or sections with less than standard designs may have lower maximum operating thresholds than those with standard designs.
Local Conditions and Perceptions	The perceptions of HOV lane users, commuters and the public, as well as any unique local conditions, should be considered in developing maximum operating thresholds.

A number of techniques may be used for assessing possible changes in vehicle-occupancy requirements. First, sketch planning methods, travel demand models, and simulation techniques that were used in the initial planning for an HOV facility may also be appropriate for use assessing potential ongoing changes. Second, data collected through ongoing monitoring program of the actual operation of an HOV facility and the adjacent freeway lanes can be used. Ongoing monitoring programs are discussed briefly in Chapter Seven and in detail in the HOV Performance Monitoring, Evaluation, and Reporting Handbook.

- Increasing vehicle-occupancy levels from 2+ to 3+. Elements to examine in considering increasing vehicle-occupancy levels from 2+ to 3+ include:
  - Number of current 3+ carpools in the HOV lane;
  - level of bus service in the HOV lane;
  - traffic volumes in the general-purpose lanes; and
  - rideshare and support programs to help 2+ carpools find additional riders.

Case Study – Lowering the Vehicle-Occupancy Requirement on the El Monte Busway in Los Angeles



In 1999, legislation was passed which lowered the vehicle-occupancy requirement on the El Monte busway on the San Bernardino (I-10) Freeway in Los Angeles from the three persons per vehicle (3+) to two persons per vehicle (2+) full-time. The California Department of Transportation (Caltrans) was directed to implement this change on January 1, 2000 and to monitor and evaluate the effects of the 2+ requirement on the operation of the busway and the freeway. Based on the operational effects that results from this change, emergency legislation was approved increasing the vehicle-occupancy requirement back to 3+ during the morning and afternoon peak-periods effective July 24, 2000.

Lowering the vehicle-occupancy requirement from 3+ to 2+ full time had a detrimental effect on the busway. At the same time, significant improvements were not realized in the general-purpose freeway lanes. Morning peak-period travel speeds in the busway were reduced from 65 mph to 20 mph, while travel speeds in the general-purpose lanes decreased from 25 mph to 23 mph for most of the demonstration. Hourly busway vehicle volumes during the morning peak-period increased from 1,100 to 1,600 with the 2+ designation, but the number of persons carried declined from 5,900 to 5,200. The freeway lane vehicle volumes and passengers per lane per hour remained relatively similar. Peak-period travel times on the busway increased by 20 to 30 minutes. Bus schedule adherence and on-time performance declined significantly and passengers reported delays.

- Decreasing vehicle-occupancy levels from 3+ to 2+. Elements to examine in considering decreasing vehicle-occupancy levels from 3+ to 2+ include:
  - Number of current 2+ carpools in the general-purpose lanes and parallel routes;
  - number of current 3+ carpools;
  - level of service in the HOV lane; and
  - traffic volumes in the general-purpose lanes.

- Variable time-of-day occupancy requirements (3+ peak/2+ off-peak). Elements to consider in examining variable time-of-day vehicle occupancy requirements include:
  - Number of 2+ and 3+ carpools by time-of-day;
  - traffic volumes in the HOV lane by time-of-day;
  - traffic volumes in the general-purpose lanes by time-of-day;
  - continuity with other HOV lanes in the area;
  - signing and enforcement; and
  - public understanding.

Chapter Six – Assessing HOV Operating Hours

This chapter examines HOV operating hours. Factors influencing HOV operating hours are described first, followed by alternative HOV operating scenarios. The chapter concludes with a discussion of techniques to assess possible changes in HOV operating hours.

In general, the operating hours of HOV facilities can be characterized by three different scenarios. These are continuous 24-hour use, extended morning and afternoon operating hours, and peak-period only operation. In addition, some facilities are open additional hours for sporting events or other special activities.

I. Factors Influencing HOV Operating Hours

Factors to be considered in assessing operating hours include the project goals and objectives, the type of HOV facility, the level of congestion in the corridor, system or regional connectivity, and enforcement and safety concerns. Each of these considerations is described briefly.

Metropolitan and Project Goals and Objectives. The goals and objectives contained in the transportation plan for a metropolitan area and those related to the specific project may influence the hours of operation. For example, areas such as Seattle and Southern California have policies relating to providing HOVs with priority treatment during all times of the day and night. As a result, most HOV lanes in these areas operate on a 24-hour basis.

Type of HOV Facility. Although no one specific operating scenario necessarily equates to a certain type of HOV facility, the orientation and design of a facility will influence the operating hours. For example, projects designed to provide HOVs with priority treatment around a specific bottleneck may operate only during congested time periods, as may contraflow facilities. Reversible lanes also require some time to open, close, reverse the direction of traffic flow, reopen, and close.

Congestion Levels in the Corridor. The level of traffic congestion on the freeway and in the travel corridor may also influence the hours of operation for an HOV facility. In some areas, such as Southern California, congested freeway conditions extend over long periods of day. As a result, the HOV lanes operate on a 24-hour basis. In other areas, HOV facilities may operate only during the most congested periods of the day.

System or Regional Connectivity. If there are multiple HOV lanes in an area, consideration may be given to coordinating the operating hours of the various facilities. Uniform operating hours can make it easier for commuters and enforcement personnel. Similar operating hours may not always be possible, however, depending on the type of HOV facilities in an area.

Enforcement and Safety. The need for enforcement during all operating periods may influence the hours an HOV facility is open. In addition, safety concerns, such as the potential for vehicles to enter a lane in the wrong direction of travel, should be considered in assessing alternative operating scenarios.

II. Alternative HOV Operating Hour Scenarios

The characteristics of the three general operating hour scenarios—24 hour, extended hours, and peak-only—for HOV facilities are described in this section, along with the use of HOV lanes during special events. Examples of the use of different operating hours are provided and the advantages, limitations, and issues associated with different scenarios.

24-Hour Operation. This approach maintains the HOV designation and operation of a facility on a 24-hour basis. In these cases, the HOV lane is open during all operating periods. Continuous 24-hour operation tends to be found with HOV lanes in separate rights-of-way and with freeway concurrent flow and exclusive two-way facilities. As could be expected, this approach is not used with contraflow or exclusive reversible HOV facilities. Examples of HOV facilities operating on a 24-hour basis include the bus-only facilities in Pittsburgh and Ottawa; the exclusive two-directional HOV lanes on I-84 in Hartford and the El Monte Busway in Los Angeles; and most of the concurrent flow lanes in Seattle and Southern California.

The 24-hour operating scenario is based on the premise or policy that HOVs should be provided with priority treatment at all times. Since congestion or incidents may occur at any time, the 24-hour designation provides HOVs with travel time savings and travel time reliability throughout the day and night. This operating scenario also allows travelers to use the HOV facility during non-commute hours. For example, recreational trips often include more than one person in a vehicle. The 24-hour operating scenario allows these individuals to use the HOV lanes, which may promote wider acceptance of the facility. Off-peak use by travelers may also help encourage peak-period use by commuters.

The 24-hour designation may also help to minimize potential confusion on the part of motorists on whether or not the HOV designation is in effect. Since the vehicle-occupancy requirement is always in effect, motorists know they should not use the lane unless they have the correct number of passengers. As a result, the continuous HOV designation can also make enforcement easier, as there is no question on the operation requirements. Twenty-four hour operation may simplify signing and lane markings. Also, there may be no need for additional general-purpose capacity during the off-peak if the facility is not congested. If congestion does exist, priority may be given to HOVs to meet specific transportation goals and objectives in an area.

Limitations and issues associated with 24-hour operation of an HOV facility include possible negative public perception if the facility is not well used during off-peak hours, the need for ongoing enforcement, and potential safety concerns. The advantages and limitations should be examined in determining the appropriate operating scenario for a specific facility.

Extended Operating Hours. Extended operating hours encompass a major portion, but not all, of the day. In most cases, HOV lanes using extended hours are open for major portions of the morning and afternoon. Although the exact hours of operation vary by facility, this scenario often encompasses the time periods from 6:00 A.M. to 11:00 A.M. and 3:00 P.M. to 7:00 P.M. These times correspond to the major commuting periods, when traffic congestion is heaviest.

Extended operating hours are currently in use with exclusive reversible HOV lanes, concurrent flow lanes, and contraflow lanes. Examples of specific facilities using this operating approach include the exclusive reversible HOV lanes in Houston, San Diego, Denver, Minneapolis, and the Northern Virginia/Washington, D.C. area; the concurrent flow HOV lanes in Miami, Orlando, and Minneapolis; and the contraflow lanes in Dallas and Boston.

Extended operating hours provide HOVs with travel time savings and travel time reliability during the periods when the general purpose freeway lanes are most likely to be congested. This approach may also represent the most logical or the only realistic scenario for some types of HOV facilities. For example, extended hours are often the most appropriate approach with exclusive reversible facilities and contraflow lanes using a separation that allows access to all HOVs.

Potential limitations of extended operating hours include confusion on the part of motorists, which makes enforcement more difficult, and the need for additional signing and pavement markings. The use of the facility during non-HOV operations may influence the level of these concerns. If an HOV facility is closed during non-HOV operating hours, which is usually the case with exclusive reversible lanes, these may not be major problems. A concurrent flow HOV lane that is open to general traffic during non-HOV operating periods will probably have to address these concerns.

Peak-Period Only Operation. The final operating scenario is to use the HOV lane only during the peak-periods in the morning and afternoon. Peak-period operation is defined more narrowly than the extended hours, usually encompassing the hours from 6:00 A.M. to 9:00 A.M. and 4:00 P.M. to 6:00 P.M., although variations are found in these hours. Some facilities use the HOV restriction only in the peak-direction of travel, while others may operate only in the morning peak-period in the peak-direction.

Peak-period operating hours are used primarily with concurrent flow and contraflow HOV lanes. Currently, concurrent flow lanes in Minneapolis, Miami, Orlando, San

Francisco, and San Jose are restricted to HOVs only during the peak-hours. The contraflow lanes on Rt. 495, the Long Island Expressway, and the Gowanus Expressway in New York operate only in the morning peak-period in the inbound direction.

Peak-period only operations present many of the same advantages, disadvantages, and issues as extended operations. Advantages include providing priority to HOVs at critical times of the day and addressing specific bottleneck problems. Depending upon the use of the facility during non-HOV operating periods, possible disadvantages include confusion on the part of commuters, more difficult enforcement, safety issues, and increased signing needs.

Extended Operating Hours for Special Events and Other Activities. A few HOV facilities throughout the country are open on a periodic basis outside the normal operating hours for special events and other activities. These may include sporting events and special activities. A number of examples highlight the use of HOV lanes to help traffic during special events. The I-394 HOV lanes in Minneapolis are open in the evening and on weekends for professional baseball, football, and basketball games and University of Minnesota football games at facilities in downtown Minneapolis. Vehicles using the HOV lanes must meet the 2+ vehicle-occupancy requirement. The I-279 HOV lane in Pittsburgh is open extended hours in the outbound direction after baseball and football games at Three Rivers Stadium in the downtown area. All traffic is eligible to use the facility to exit the stadium.

Opening these and other HOV facilities for special events can provide a number of benefits. First, the HOV lanes can help manage traffic during major events and can improve the traffic flow into and out of the sports stadium or other facility. Second, opening an HOV lane for special events provides opportunities for travelers to use the facility who might not be able to use the lanes during their regular commute. Using an HOV lane during a special event can be a good way to introduce the facility to non-users and to build public acceptance and support.

Opening an HOV lane for special events is not without possible concerns, however. Since many travelers may be first time users, care should be taken to provide advance information on access points, vehicle-occupancy requirements, and other operating instructions. Additional or special signs and enforcement may also be needed to ensure safe operation of an HOV facility during special events.

HOV restrictions may also be lifted in the case of crashes, emergencies, and weather conditions that affect the operation of the overall system. In these cases, the HOV lanes may be used to help with emergency evacuations or to move traffic past a major crash.

III. Techniques for Assessing Changes in HOV Operating Hours

This section presents techniques for assessing the impact of possible changes in HOV operating hours. The sketch planning, travel demand models, and simulation techniques used in the initial planning for an HOV facility may be appropriate for use in assessing changes in the HOV operating hours. Data collected through ongoing monitoring of the actual operation of an HOV facility and the adjacent freeway lanes is typically of greater use, however. Ongoing monitoring programs are discussed briefly in Chapter Seven and in detail in the HOV Performance Monitoring, Evaluation, and Reporting Handbook. *The political and policy ramifications of any change should also be considered. Since transportation agencies are public agencies, supported by public funds, consideration of possible changes should consider public and political support.*

- Extending peak-period operation to 24/7 operation. Elements to examine in considering extending peak-period HOV operation to 24/7 operation include;
  - Traffic volumes and congestion levels on the freeway throughout the day;
  - the number of carpools and buses throughout the day; and
  - any costs associated with extending operations and enforcement.

- Lengthening peak-period operations. Elements to examine in considering lengthening peak-period operations include:
  - Traffic volumes and congestion levels in the HOV lane;
  - traffic volumes and congestion levels in the freeway lanes;
  - the number of carpools and buses in the freeway lanes during the period being considered for extending hours; and
  - any costs associated with extending operations and enforcement.

- Reducing peak-period operations. Elements to consider in reducing peak-period operations include:
  - Traffic volumes and congestion levels in the HOV lane;
  - traffic volumes and congestion levels in the general-purpose lanes;
  - the number of carpools and buses in the HOV lane during the time to be reduced; and
  - the costs of changes to signing and other elements that may be required.

- Reducing 24/7 peak-periods. Elements to consider in reducing 24/7 to peak-period operations include:
  - Traffic volumes and congestion levels in the HOV lane;
  - traffic volumes and congestion levels in the general-purpose lanes;
  - the number of carpools and buses in the HOV lane during the time to be reduced; and
  - the costs of changes to signing and other elements that may be required.

- Modify 24/7 to exclude evening and weekend period operation. Elements to consider in modifying operation to exclude evening and weekend operation include:
  - Traffic volumes and congestion levels in the HOV lane;
  - traffic volumes and congestion levels in the general-purpose lanes;
  - the number of carpools and buses in the HOV lane during the time to be reduced; and
  - the costs of changes to signing and other elements that may be required.

Chapter Seven – Performance Monitoring and Policy Implications

This chapter provides the link back to the HOV performance monitoring program and to possible policy implications. It also highlights some of the possible issues that may be encountered with operating HOV facilities. More detailed information on monitoring HOV facilities is provided in the HOV Performance Monitoring, Evaluation, and Reporting Handbook.

I. Performance Monitoring

Once an HOV project has been opened, the focus of the responsible agency or agencies changes from planning, designing, financing, and constructing to managing and operating the facility. As highlighted in this section, key elements to be considered in effectively managing and operating HOV facilities include performance monitoring, incident management, enforcement, public and policy maker outreach efforts, and ongoing consideration of enhancements. Real-time monitoring of freeways and HOV lanes, through closed-circuit television cameras (CCTV) and other technologies, is an important component of proactive management and operation of the transportation system in many metropolitan areas.

Many areas use multi-agency teams to coordinate the management and operation of freeway HOV facilities. These teams are usually comprised of representatives from the state department of transportation, the regional transit agency, the state highway patrol, the metropolitan planning organization, local communities, and FHWA and FTA. Depending on the institutional structure in an area, other possible groups to involve include local police departments, the regional rideshare agency, transit operators, emergency management services (EMS), and air quality or environmental agencies. The exact agencies and groups included on management and operation teams should be matched to the roles, responsibilities, and institutional structures of a specific area. Further, if an area has an advanced transportation management system (ATMS), representatives from the state department of transportation, transit agency, state patrol, and other agencies may be located in the operations center or many interact and share information on a regular basis.

Multi-agency management and operation teams provide numerous benefits for helping ensure the efficient operation of HOV facilities. Multi-agency teams provide an ongoing mechanism for communication, cooperation, and coordination among agencies. They provide a regular forum for the discussion of issues and opportunities, and allow agencies to better coordinate projects and activities.

Monitoring conditions on freeways and freeway HOV facilities is a key element of successful proactive management and operational efforts. Many major metropolitan areas use a variety of advanced technologies to monitor the freeway and HOV system. ATMS provides real-time monitoring, incident detection, and rapid response capabilities.

In addition, many areas conduct ongoing monitoring and performance evaluations of HOV facilities. These efforts combine to enhance the day-to-day operation of HOV and freeway facilities and to provide the information needed for ongoing operational changes.

Ongoing performance monitoring programs help identify the benefits accrued from a project, determine if the goals and objectives are being met, and identify operating problems or issues that may need to be addressed. Evaluations provide an opportunity to ascertain the degree to which the desired results are, in fact, occurring. Performance monitoring programs provide an official database for a project. This information can help ensure that all groups are utilizing the same data, assisting to clarify any possible disagreements over the impact of a project.

The information collected as part of an ongoing performance monitoring program has value for operating decisions relating to the HOV facility. Information on usage, violation rates, and accidents are critical for ensuring the efficient and safe operation of a facility. Monitoring these and other aspects of the HOV lane as part of a performance process will help identify problems that may need to be addressed. For example, changes in operating hours, vehicle-occupancy requirements, bus service levels, and access points may be necessary. Longitudinal data on the use of a facility serves a critical operations function. This information can also be used to evaluate the marketing and public information programs associated with a facility, as well as helping to identify if additional marketing is needed.

The results of performance monitoring programs are also beneficial in future planning efforts. The information generated can be used to calibrate planning and simulation models for future use. Calibrating models with the results of local evaluations will ensure that they accurately reflect actual experience, provide a valuable check on the modeling process, and improve the future capabilities of the models. In addition, the results from a monitoring program, along with the experience gained from a project, can enhance the decision-making process on future projects.

Performance monitoring programs may also be needed to meet federal or state requirements. Different funding sources and programs may require ongoing evaluations or other documents of project results. Even when not a requirement, evaluations of HOV projects can be useful to help justify future funding for similar facilities in an area.

It is important that performance monitoring programs cover all elements of an HOV facility. Depending on the specific project, these might include HOV lanes, direct access connections, park-and-ride and park-and-pool lots, transit stations, new or enhanced transit services, and the general-purpose freeway lanes. In some instances it may be difficult to separate the impact of the various components. The performance monitoring program should be designed to examine the individual components and the full HOV system.

Major elements in a performance monitoring program include articulating project goals and objectives, identifying measures of effectiveness, identifying data needs and data collection methods, collecting and analyzing the data, and presenting the results. Common data collection efforts focus on vehicle volumes, passenger volumes, travel speeds, trip times, accident rates, and violation rates. The HOV Performance Monitoring, Evaluation, and Reporting Handbook provides a comprehensive description of a monitoring and evaluation program.

II. Process and Stakeholder Involvement

As described in Chapter Three, the appropriate agencies, groups, and individuals should be involved in the consideration of changes in the operation of an HOV facility. Many areas use multi-agency teams to help coordinate planning, designing, and operating HOV facilities. These groups provide the logical forum for the discussion of possible operating changes. If a multi-agency team does not exist, one could be formed to consider specific operating issues. Another option would be to hold meetings with representatives from the appropriate agencies. In addition, ongoing communication with elected officials, other policy makers, and the media should occur.

The exact agencies and groups to involve in discussions and decisions on changes in HOV operations may vary by area. Factors that may influence the groups to involve include the institutional arrangements in an area, the type of HOV facility, and the nature of the change being considered. Examples of the groups frequently participating in HOV operational efforts and their roles are highlighted next.

The process for assessing possible HOV operating strategies should be similar to the one used to plan a project and should be coordinated with ongoing monitoring and evaluation efforts. Ideally, the need for possible modifications in HOV operations should emerge from an established monitoring program. Information on vehicle and passenger volumes, travel speeds, travel-time savings, violation rates, and accidents should form the basis of an on-going monitoring and evaluation program. This information can be used to identify possible problems and potential changes.

The key elements of the process for assessing, implementing, and monitoring possible changes in HOV operations are shown in Figure 4 and highlighted below. The exact steps may vary depending on the local situation.

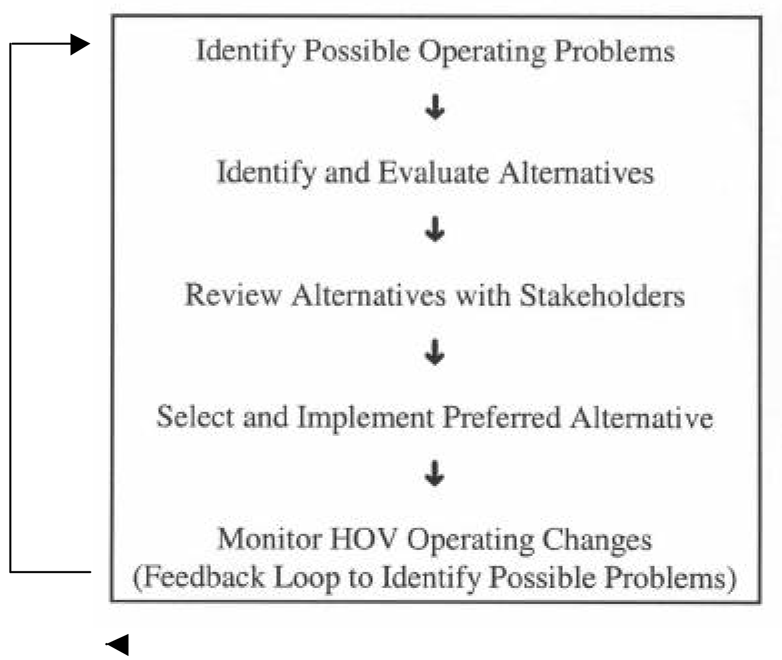


Figure 4. Process for Assessing, Implementing, and Monitoring Changes in HOV Operations

- **Identify Possible Operating Problems**. Information from the on-going monitoring program should be used to identify potential operating problems, such as facilities reaching capacity or high violation rates. A good database on vehicle and passenger volumes, travel speeds, travel time savings, violation rates, and accidents should alert agency personnel to possible problems. Regular visual monitoring of a facility, such as personnel driving the corridor or surveillance through Advance Transportation Management Systems (ATMS) can also help identity potential problems.

- **Identify and Evaluate Alternatives**. Possible approaches to addressing the issues are identified and evaluated in this step. As an example, possible alternatives that may be considered when an HOV lane is reaching capacity include increasing the vehicle-occupancy requirement, pricing strategies, sticker programs, restricting some user groups, eliminating access points, and metering some user groups. The identified options can be evaluated using available data and various planning models and methods.

  The analysis methods, data needs, and level of effort should be matched to the types of operational changes being considered. For example, consideration of extending or reducing operating hours on a part-time HOV lane should include examination of vehicle and person volumes, travel speeds, and trip time reliability on the HOV and general-purpose lanes during the specified time period. The possible effects of an operational change on other HOV lanes in the area should also be examined.

- **Review Alternatives with Stakeholders**. In this step the results of the evaluation are discussed with key stakeholder groups. As discussed previously, stakeholders usually include other agency personnel, policy makers, and commuters in the corridor. The groups and individuals involved should be matched to the nature of the problems being examined and the solutions being considered.

- **Select and Implement Preferred Alternative**. In this step the preferred alternative is selected and implemented. Input from technical staff, policy makers, and commuters may be used in identifying the preferred alternative. A plan for implementing the operating change should be developed and followed. Key elements of a successful implementation effort include public information and outreach activities, necessary changes in signing, and other possible modifications. Ensuring that HOV user groups and commuters are informed of the change and that adequate enforcement is provided represent two key elements associated with implementing HOV operational changes.

- **Monitor HOV Operating Changes**. The monitoring program should continue to track the affects of the changes made in the operation of an HOV facility. The information collected through the ongoing monitoring efforts should be used to evaluate the change and to provide a feedback loop to continue to identify possible operating problems.

III. Possible Issues with Operating HOV Facilities

This section highlights possible issues related to vehicle eligibility requirements and operating hours. It also describes possible approaches to addressing these issues.

Demand Exceeding Capacity at 2+ Occupancy Requirement. A facility with a 2+ designation that may be at or reaching capacity may be examined for increasing the occupancy requirement to 3+. Varying occupancy requirements by time-of-day is another possible alternative.

Not Enough Vehicles at 3+ Occupancy Requirement. Changes in vehicle-occupancy levels may be considered in response to under use and over use of an HOV facility. For example, an underutilized HOV lane with a 3+ occupancy requirement may be considered for a change to a 2+ level.

Bottleneck Caused Before Start or the End of HOV-Period. In some cases non-HOVs may enter the HOV lane just before the start of the HOV restricted time period and thus be in the HOV lane during the restricted period. In other cases, non-HOVs may wait on the shoulder or other location for the HOV restricted period to end so they can enter the lane. Both of these situations may cause *vehicles not meeting the occupancy requirements to be in an HOV lane during the HOV-only operating period and may cause the facility to become congested.*

Use of Lanes by Unauthorized Vehicles. Issues may be encountered with the use of HOV lanes by unauthorized vehicles. These vehicles may include lower-occupant vehicles, hybrids, and law enforcement personnel in their own vehicles. Enforcement of vehicle-occupancy requirements and other policies are critical to the successful operation of HOV facilities. Visible and effective enforcement promotes fairness and maintains the integrity of the HOV facility to help gain acceptance of the project among users and non-users.

Effective enforcement usually includes a number of components. The six general elements that should be considered in developing and conducting an enforcement program include the legal authority to enforce a facility, the nature of citations for violations and the level of fines, the general enforcement strategies, the specific enforcement techniques, funding, and communicating the program elements to users, non-users, and the public.

Enforcement strategies for HOV facilities can generally be categorized into four basic approaches. These are routine enforcement, special enforcement, selective enforcement and self-enforcement. All of these strategies may be appropriate for consideration with the various types of HOV projects. The most effective approaches and techniques will vary somewhat for different facilities. For example, enforcement of barrier-separated facilities is easier than for buffer-separated facilities.

A variety of enforcement techniques can be used to monitor HOV facilities. These techniques focus on providing surveillance of the lanes, detecting and apprehending violators, and issuing citations or warnings to violators. Examples of approaches include stationary patrols, roving patrols, team patrols, multipurpose patrols, electronic monitoring, citations or warning by mail. Most areas use a combination of enforcement techniques.

Special Event Needs. The location of a new special event venue may provide the opportunity to consider extending the hours of operation for an HOV facility or opening it to general-purpose traffic to assist with managing traffic for the event.

Adjustments Needed To Operating Hours. As described previously, the hours of operation may be adjusted over the life of a project. HOV facilities may be operated on a 24-hour basis during major portions of a day, or only during the peak-periods. During non-HOV use times a lane may be open to general-purpose traffic, closed to all traffic, used as a shoulder, or used for some other purpose.

Access Controls. Consideration may also be given to the ingress and egress provided along an existing HOV lane. Approaches that may be examined include adding access points, removing access points, and metering carpools at access points.

Chapter Eight – Case Studies

This chapter highlights case study examples related to changing vehicle eligibility requirements, including vehicle-occupancy levels, and operating hours. The following case studies are suggested. These case studies have been selected to highlight documented experience with changes in vehicle eligibility requirements, including vehicle-occupancy levels and value pricing projects, and operating hours.

I. Houston, Texas

I-10 West (Katy) Freeway HOV Lanes, This case study will highlight the changes in vehicle eligibility, vehicle-occupancy levels, value pricing, and operating hours on the I-10 West (Katy) Freeway in Houston, Texas. The various changes are highlighted below.

Vehicle Eligibility and Vehicle-Occupancy Requirements	Date
Buses and authorized vanpools	October 1984
Buses, authorized vanpools and authorized 4+ carpools	April 1985
Buses, authorized vanpools, and authorized 3+ carpools	September 1985
Buses, vanpools and 2+ carpools	November 1986
Buses, vanpools and 3+ carpools in A.M. peak hour	October 1988
Buses, vanpools and 3+ carpools in A.M. and P.M. peak hours	September 1991
Value pricing—2 person carpools use lane during 3+ period for fee	January 1998

The Katy HOV lane, located on the I-10 Freeway on the west side of Houston, is 13 miles in length. It is a one-lane, barrier-separated, reversible HOV lane located in the freeway median. The vehicle eligibility and the vehicle-occupancy requirements on the Katy HOV lane have been changed a number of times since the facility opened in 1984. Some of these changes were based on the lack of previous experience with HOV lanes, while others were due to the success of the lane.

The Katy HOV lanes were first opened to buses and authorized vanpools only. The authorization process included insurance requirements, driver training, and vehicle inspection. Approximately 50 vehicles used the lane during the morning peak-hour with this requirement. Due to this low level of use, the lanes were opened to authorized 4+ carpools after six months of operation. This change added only about 10 vehicles to the morning peak- hour volume on the lane.

Six months later, the requirements were lowered to 3+ authorized carpools, which added some 100 vehicles to the morning peak hour traffic stream. In April 1986 the vehicle-occupancy level was lowered to 2+ carpools and the authorization requirement was discontinued. The morning peak hour volumes increased to approximately 1,200 vehicles very quickly after this change (31).

Carpool volumes in the HOV lane, as well as vehicle volumes in the general-purpose freeway lanes, increased over the next year, primarily due to the economic recovery occurring in the Houston area. Within a year, morning peak hour vehicle volumes on the HOV lane were regularly reaching or exceeding 1,500. The congestion resulting from these volumes and the design of the facility reduced the travel time savings and travel time reliability bus riders and carpoolers had come to expect. In response to lower travel speeds in the HOV lane and complaints from bus passengers, the vehicle-occupancy requirement was increased from 2+ to 3+ during the period from 6:45 to 8:15 a.m. in October 1983. At all other times, including the afternoon peak hour, the 2+ occupancy requirement was maintained.

The morning peak hour total vehicle volume dropped from approximately 1,400 to 510 immediately after the change was made, representing a 64 percent reduction in vehicle volumes. A corresponding drop of 33 percent in person volume also occurred. Utilization levels during the morning peak hour increased over the next year, reaching 660 in March of 1989, but declining to 611 in December of 1989. Although the vehicle and passenger volumes declined during the morning peak hour, the AVO increased. The AVO was 3.1 prior to the change, 4.7 in March 1989, and 4.5 in December 1989 (31).

The trends in the morning peak period highlight other impacts of the occupancy change. Total vehicle volumes declined from some 8,780 before the change to 7,523 in December of 1989, representing a 14 percent decline. The major shift was in 2+ carpools, which declined by some 41 percent, while 3+ carpools increased by 68 percent, bus ridership by 8 percent, and vanpool passengers by 2 percent. The results of surveys and enforcement data indicate that some 2+ carpools shifted to earlier time periods. Some of these vehicles enter the lane before the restricted period and thus are on the facility when the 3+ requirement takes effect. Further, survey results indicated that some 2+ carpools changed their travel routes to use the newly opened Northwest HOV lane, which had a 2+ requirement (31).

The vehicle-occupancy requirements on the Katy HOV lane have been modified further since the change to the morning 3+ peak hour requirement. In May 1990, the 3+ restricted period was modified slightly to 6:45 - 8:00 a.m. The 3+ requirement was added to the afternoon peak hour, from 5:00 to 6:00 p.m., in September 1991.

Further, in 1989 a demonstration project, called QuickRide, was implemented allowing 2+ carpools to use the HOV lane for a fee during the 3+ period. The demonstration, which uses an electronic toll collection system, charges for two-person carpools to use the lane. An initial group of 300 individuals were provided with toll tags on a first-come, first-serve basis.

As of June 1998, there were 390 active accounts for the QuickRide project and 521 active transponders. Daily use in 1998 averaged in the range of 125 to 150 two-person carpools. Use during June has been lower, in the 90 to 120 range. This drop may be related to the summer school break (32).

II. Los Angeles, California

El Monte Busway, San Bernardino Freeway. This case study will highlight the changes in vehicle eligibility requirements, vehicle-occupancy requirements, and operating hours on the El Monte Busway, San Bernardino Freeway (I-10) in Los Angeles, California. The various changes are highlighted below.

January 1973	➔	Partial opening of Busway. Operating hours 6:00 A.M. to 10:00 A.M. and 3:00 P.M. to 7:00 P.M., Monday-Friday
June 1974	➔	Opening of final 3.5 miles.
August 1974	➔	SCRTD bus operators strikes—3+ carpools allowed on Busway.
October 1974	➔	Strike settled—3_ carpool use discontinued.
October 1976	➔	Mixed-mode operation—3+ carpools allowed on Busway.
1977	➔	Operating hours extended to weekends (6:00 A.M. to 10:00 A.M. and 3:00 P.M. to 7:00 P.M.).
1981	➔	Operating hours extended to 24 hours a day, 7 days a week (24/7).
1989	➔	One-mile extension into downtown Los Angeles opened.
January 2000	➔	Vehicle-occupancy requirements lowered to 2+ full time as required by California Senate Bill 63.
July 2000	➔	Vehicle-occupancy requirement raised to 3+ during morning and afternoon peak periods and 2+ at all other times as required by Assembly Bill 769.

III. Change in Operating Hours—Weekend and Evenings on Selected HOV Lanes, Seattle, Washington

This case study will highlight the recent study and change in operating hours on some HOV lanes in the Seattle area, which are now open to general traffic on weekends and evenings.

IV. Virginia

I-395 (Shirley Highway), Northern, Virginia. This case study will highlight the changes in vehicle requirements and vehicle-occupancy levels on the Shirley Highway since the opening of the initial bus-only lane demonstration in 1969. It will include examination of allowing low-emission vehicles in the early 1990s and hybrid vehicles in 2000.

Change in Vehicle Occupancy Requirements B I-66, Northern Virginia. I-66 was open from I-495 (Capital Beltway) into the District of Columbia in December 1982. The lengthy and often controversial planning process for the facility, which started in 1959, resulted in the freeway being restricted to HOVs only from 6:30 a.m. to 9:00 a.m. in the eastbound direction and from 3:30 to 6:30 p.m. in the westbound direction. A 4+ vehicle-occupancy requirement was used on the facility until a congressional mandate changed it to 3+ in 1986. In addition, the Metrorail Orange Line operates in the median of I-66 with four stations located in the section.

In 1994, Congress authorized the Commonwealth of Virginia to conduct a one-year demonstration using a 2+ occupancy requirement for the section of I-66 inside the Beltway. A 2+ requirement is in use on the concurrent flow HOV lanes on I-66 beyond the Beltway. The Virginia Department of Transportation (VDOT) in conjunction with other agencies and an advisory committee, evaluated this test. Data collection took place in the fall of 1994, before the occupancy-requirement was lowered to 2+, and again in November of 1995, approximately one year after the change.

Information on changes in vehicle volumes, passenger volumes, average vehicle occupancy (AVO), and transit ridership was examined by VDOT. Total vehicle volume increased by 62 percent in the morning peak-hour and by 51 percent in the morning peak period. Total vehicle person movement rose by 50 percent in the peak hour and 35 percent in the peak-period. Automobile volumes and person movement total increased roughly the same percentages given the small number of other vehicles. Total HOV volumes increased by 178 percent in the peak hour and 133 percent in the peak period. The large increase in HOV volumes was a result of the reduction in 2+ violations (29).

The reclassification of 2+ carpools from violators to HOVs was a major factor in the reduction in violation rates. A decline in single-occupancy vehicle violations also occurred, however. After the change to 2+, the number of single-occupant vehicles decreased by 51 and 22 percent for the peak hour and the peak period, respectively. The all-vehicle AVO declined from 2.49 to 2.30 in the peak hour and 2.38 to 2.13 in the peak period, but was more than counterbalanced in total facility carrying capacity by the increase in overall vehicle flow.

The demonstration and monitoring activities continued in 1996 and 1997. Data collected in the spring and fall of 1996, and the spring of 1997 showed little change from the trends noted previously. Vehicle volumes, passenger volumes, and AVO fluctuated slightly, but no major changes were reported (28, 30).

V. San Diego, California

This case study will examine the following changes in vehicle requirements on the I-15 HOV lanes in San Diego, California, including the introduction of value pricing.

I-15 HOV Lane ExpressPass and FasTrack Demonstration, San Diego. The two-lane exclusive HOV facility on I-15 is approximately 8 miles in length and is located on the northeast side of San Diego. There is one entrance and one exit. The facility was opened in 1988 with a 2+ per-vehicle occupancy requirement. The lanes are open in the southbound direction from 6:00 to 9:00 a.m. and in the northbound direction from 3:00 to 6:30 p.m. and are closed at other times.

The I-15 Freeway HOV Pricing project was one of the congesting pricing demonstrations funded as a result of the ISTEA of 1991. The project included two phases to test allowing single-occupant vehicles to use the I-15 HOV lanes for a fee. The objectives of the demonstration included testing value pricing as a method of managing congestion on the freeways lanes, managing demand on the HOV lanes, expanding transit and ridesharing services in the corridor, and enhancing air quality in the region (34).

During the Interim Operations phase of the demonstration, called ExpressPass, a limited number of monthly permits were sold to motorists on a first-come, first-serve basis. Drivers with permits could use the HOV lanes without meeting the vehicle-occupancy requirement, while carpools and vanpools with 2 or more persons continued to use the lanes for free. The monthly fee was first set at $50 in December 1996 and 500 permits were sold. In 1997, the number of permits issued and the monthly fee were increased to 700 and $70, respectively. By the end of the Interim Operations Phase in March 1998, 1,000 passes were available.

The full Implementation phase, called FasTrak, started on March 30, 1998. Electronic toll collection and variable fees for single-occupant vehicle use of the

HOV lanes were tested in this phase. Currently, the fees range from $0.50 to $4.00, depending on the congestion level in the general-purpose lanes. In April 1998, 3,500 transponders had been distributed to 2,500 customers (35).

The preliminary assessment of the ExpressPass portion of the project indicated that the percentage of HOVs using the I-15 HOV lanes increased from 85 percent to 89 percent of the total traffic. The percentage of the single-occupant vehicles illegally using the facility declined from a high of 15 percent before the start of the test to 3 percent during February and March 1997. Overall, total vehicle volumes in the HOV lane increased by 12 percent (34). The value pricing project is continuing on the I-15 HOV lanes, with use levels increasing.

1998	➔	Opening with 2+ requirement.
1996	➔	ExpressPass—Interim value pricing (single occupant vehicles pay monthly fee).
1998	➔	ExpressPass—Variable pricing for single occupancy vehicle use.

Appendix A – References and Additional Resources

Appendix B – Glossary of Terms

This appendix contains a glossary of terms associated with HOV performance monitoring, evaluation, and reporting. It focuses on terms used in the handbook. The glossary is based on the glossaries for the NCHRP HOV Systems Manual and the AASHTO Guide for High-Occupancy Vehicle Facilities.

Advanced Traffic Management System (ATMS): Remotely operated traffic management system for monitoring and managing operations of a freeway system including HOV lanes and arterial streets. Major elements of the system include surveillance, communications, and controls.

Articulated Bus: An extra-long, high-capacity segmented bus that has the rear portion flexible but permanently connected to the forward portion with no interior barrier to hamper movement between the two parts. The seated passenger capacity is 60 to 80 persons with space for many standees, and the length is from 18.3 to 21.3 m (60 to 70 ft). The turning radius for an articulated bus is usually less than that of a standard urban or intercity bus.

At-grade Access: Ingress/egress between an HOV facility and the adjacent general-purpose lanes that occurs with a direct merging maneuver. Contrast with Direct (Grade-separated) Access Ramps.

Auto Free Zone: An area, usually within a densely developed corridor, where all autos or all motorized vehicles are banned.

Automated Vehicle Identification (AVI): Use of overhead or roadside detectors to read and identify vehicles equipped with a transponder or similar device. Used for electronic toll collection and traffic management.

Automatic Vehicle Location (AVL): The use of advanced technologies such as global positioning systems (GPS) to monitor the location and movement of vehicles.

Average Vehicle Occupancy (AVO): The number of people divided by the number of vehicles (including buses) traveling past a specific point over a given time period.

Barrier-separated HOV Facility: A roadway or lane(s) built within the freeway right-of-way that is physically separated by barriers or pylons from other freeway lanes and is designated for the exclusive use of high-occupancy vehicles during at least portions of the day. These facilities can operate as reversible flow (i.e., inbound in the morning and outbound in the evening) or two-way (i.e., one or more lanes operating in each direction) (24).

Benefit-cost Ratio (B/C): The ratio of the dollars of discounted benefits achievable to a given outlay of discounted costs (TRB, Urban Public Transportation Glossary, 1989).

Buffer Separation: A roadway area that is used to separate an HOV lane from a general-purpose lane.

Bus: A self-propelled, rubber-tired road vehicle designed to carry a substantial number of passengers, commonly operated on streets and highways. A bus has enough headroom to allow passengers to stand upright after entering (TRB, Urban Public Transportation Glossary, 1989).

Bus Malls: Bus or transit streets that are reserved exclusively for use by public transit vehicles.

Bus Priority System: A system of traffic controls in which buses are given special advantages over other mixed-flow traffic (e.g., preemption of traffic signals or preferential lanes).

Bus Rapid Transit (BRT): While a precise definition of BRT is elusive, it is generally understood to include bus services that are, at a minimum, faster than traditional "local bus" service and, at maximum, include grade-separated bus operations. Essential features of BRT systems are some form of bus priority, faster passenger boarding, faster fare collection, and a system image that is uniquely identifiable (TCRP project [Implementation Guidelines for Bus Rapid Transit Systems] A-23 on-line report description).

Busway / HOV Facility in Separate Right-of-Way: A roadway or lane(s) developed in a separate right-of-way and designated for the exclusive use of high-occupancy vehicles (commonly buses only) (24).

Capacity, Design (or roadway capacity): The maximum number of vehicles (vehicle capacity) or persons (person capacity) that can pass over a given section of roadway in one or both directions during a given period of time under prevailing environmental, roadway, and roadway user conditions, usually expressed as vehicles per hour or persons per hour. Operational capacity for an HOV lane should be less than this.

Carpool: Any vehicle (usually a private automobile) or arrangement in which two or more occupants, including the driver, share the use, cost, or both traveling between fixed points on a regular basis.

Central Business District (CBD): That portion of a city which serves as the primary activity center. Its use is characterized by intense business activity that serves as a destination for a significant number of daily work trips.

Clean Air Act Amendments of 1990 (CAAA): Federal legislation that establishes new requirements in metropolitan areas and states where National Ambient Air Quality Standards (NAAQS) attainment could be a problem.

Commute Trips: Trips that are taken on a daily or regular basis to work.

Concurrent Flow HOV Facility, Buffer-separated: A non-physically separated lane(s) containing buffer separation that is oriented to operate in the same direction as the adjacent general-purpose lanes. The facility is commonly the inside lane(s) of the freeway cross section, adjacent to the median barrier, and it is designated for the exclusive use of HOVs during at least portions of the day (24).

Concurrent Flow HOV Facility, Non-separated: A designated lane containing no buffer separation with the adjacent general-purpose lanes and oriented to operate in the same direction as the adjacent general-purpose lanes. The facility is commonly the inside lane and adjacent to the median barrier. Non-separated facilities commonly serve HOVs during portions of the day, reverting to a general-purpose lane during other periods (24).

Congestion Pricing: The policy of charging drivers a fee that varies with the level of traffic on a congested roadway. Congestion pricing is designed to allocate roadway space, a scarce resource, in a more economically feasibly manner. Synonym: congestion-relief tolling.

Contraflow HOV Facility: A designated freeway lane or lanes (commonly the inside lane in the off-peak direction of general-purpose travel) designated for exclusive use by HOVs traveling in the peak direction during peak commuting periods. The lane is usually separated from the off-peak direction general-purpose lanes by a moveable barrier or plastic pylons (24).

Corridor: A broad geographical band that identifies a general directional flow of traffic. It may encompass streets, highways, and transit route alignments.

Cost-Benefit Analysis: An analytical technique that compares the societal costs and benefits (measured in monetary terms) of proposed programs or policy actions. Identified losses and gains experienced by society are included, and the net benefits created by an action are calculated. Alternative actions are compared to allow selection of one or more that yield the greatest net benefits or benefit-cost ratio (TRB, Urban Public Transportation Glossary, 1989).

Deadheading: Segment of a trip made by a transit vehicle not in revenue service.

Delay: The increased travel time experienced by a person or vehicle due to circumstances that impede the desirable movement of traffic. It is measured as the time difference between actual travel time and free-flow travel time.

Department of Transportation (DOT): State agency responsible for administering federal and state highway funds.

Diamond Symbol: A uniform traffic control symbol used on signing and pavement markings to designate the restricted usage on HOV facilities.

Differential Pricing (Variable Pricing): Time-of-day pricing and tolls that vary by other factors like facility location, season, day-of-week, or air quality impact.
Direct (Grade-separated) Access Ramps: Ramps that provide ingress/egress between HOV facilities and support facilities or cross streets. Ramps of this type include flyover ramps, freeway-to-freeway direct connections, drop ramps, or T-ramps. Contrast with At-grade Access.

Directional Split: The distribution of traffic flows on a two-way facility.
Drop Ramp: This direct (grade-separated) access ramp design gets its name because it "drops" to the HOV facility from a cross street.

Dynamic Pricing: Tolls that vary in response to changing congestion levels, as opposed to variable pricing that follows a fixed schedule.

Electronic Toll Collection (ETC): This refers to electronic systems that collect vehicle tolls, reducing or eliminating the need for tollbooths and for vehicles to stop.

Emergency Vehicle: Any vehicle generally used in responding to an incident that has caused or may lead to life or injury threatening conditions or destruction of property. Examples are police, fire, and ambulance vehicles as well as tow trucks and maintenance vehicles.

Enforcement: The function of maintaining the rules and regulations to preserve the integrity of an HOV facility.

Federal Highway Administration (FHWA): Part of the U.S. Department of Transportation. FHWA is responsible for administering all federal-aid highway programs.

Federal Transit Administration (FTA): Formerly the Urban Mass Transportation Administration, part of the U.S. Department of Transportation. FTA is responsible for administering all federal-aid public transportation programs.

Flyover Ramp: This ramp design accommodates direct, high-speed connections between the general-purpose freeway lanes, park-and-ride lot, or other roadway with the HOV lane. These ramps get their name because they "fly over" the roadway to provide direct ingress/egress.

Freeway-to-Freeway Direct HOV Connections: A ramp that provides a direct connection at the interchange of an HOV facility within one freeway right-of-way to an HOV facility within another freeway.

General-Purpose Lanes: Travel lanes which are open to all vehicle types and/or occupancy levels along the roadway.

High-Occupancy Toll (HOT) Lanes: HOV facilities that allow lower-occupancy vehicles, such as solo drivers, to use these facilities in return for toll payments, which could vary by time of day or level of congestion.

High-Occupancy Vehicle (HOV): Motor vehicles carrying at least two or more occupants including the driver. An HOV could be a transit bus, vanpool, carpool, or any other vehicle that meets the minimum occupancy requirements, usually expressed as either two or more, three or more, or four or more persons per vehicle.

High-Occupancy Vehicle (HOV) Lane: An exclusive traffic lane or facility limited to carrying high-occupancy vehicles (HOVs) and certain other qualified vehicles.

High-Occupancy Vehicle (HOV) System: The collective application of physical facilities to support HOV operations, including HOV lanes, park-and-ride lots, park-and-pool lots, and/or other supporting facilities that are administered so as to effectively integrate all physical elements into a unified whole.

Ingress/Egress: The provision of access to/from an HOV or park-and-ride facility.

Inherently Low Emission Vehicles (ILEV): Alternative fueled clean air vehicles. Related terms include Zero-Emission vehicles (ZEVs), Ultra-Low-Emission (ULEV), and Super-Ultra-Low-Emission (SULEV) vehicles powered by alternative fuels.

Intelligent Transportation Systems (ITS): Advanced technologies and communication systems. In this guide, their application is to provide a remotely operated system for monitoring and managing the operation of an HOV and/or freeway facility to better assure acceptable traffic operation and improved responsiveness to incidents. Major elements are (a) surveillance—collection and processing of data by detectors and visible verification by closed circuit television, toll tags, or inductance loops; (b) communications—presentation of operational information to motorists through signs, delineation, signals, and/or auditory means; and (c) control—application of traffic restraints or direction of flow by signs, barrier gates, and signals.

Intermodal Facilities: Locations that allow travelers to change between transportation modes.

Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA): Federal legislation that mandated the way transportation decisions were made and funded over fiscal years 1992-1997. The Transportation Equity Act for the 21st Century was enacted June 9, 1998, as Public Law 105-178. TEA-21 authorizes the Federal surface transportation programs for highways, highway safety, and transit for the 6-year period 1998-2003.

Level of Service (LOS): A descriptive measure of the quality and quantity of transportation service provided the user that incorporates finite measures of quantifiable characteristics such as travel time, travel cost, number of transfers, etc. Operating characteristics of levels of service for motor vehicles can be found in the latest edition of the Highway Capacity Manual.

Line Haul: That portion of commute trip that is express (non-stop) between origin and destination.

Local Bus Service: Bus routes and service characterized by frequent stops and slow operating speeds.

Mode Shift: The shift of people from one mode to another (i.e., SOVs to HOVs).

National Environmental Policy Act (NEPA): Legislation enacted in 1969 that requires federally funded projects to conduct an environmental impact study (EIS) to evaluate potential impacts.

National Highway System (NHS): Interstate highways and other roads designated as important for interstate travel, national defense, intermodal connections, and international commerce.

National Intermodal Transportation System (also known as National Transportation System): Integrated system connecting major transportation facilities.

Nonattainment Area: A geographic area in which the level of a criteria air pollutant is higher than the level allowed by the NAAQS.

Off-Line Station: A transit station that provides safe and sheltered locations for passengers to board buses or transfer between different bus routes or services, which is located adjacent to the freeway or at a point farther away from the HOV lane facility (contrast location with On-line Station).

Off-Peak Direction: The direction of lower demand during a peak commuting period. In a radial corridor, the off-peak direction has traditionally been away from the CBD in the morning and toward the CBD in the evening.

On-line Station: A transit station that provides a safe and sheltered location for passengers to board buses or transfer between different bus routes or services, which is located directly along an HOV lane (contrast location with Off-line Station).

Paratransit Vehicle: Any form of intraurban demand-responsive vehicle such as taxis, carpools, etc., that are available for hire to the public. They are distinct from conventional transit as they generally do not operate on a fixed schedule.

Park-and-Ride (P&R) Lot: A parking facility where individuals access public transportation as a transfer of mode, usually from their private automobiles. Public transportation usually involves express bus from the lot to a central business district or major activity center:

Informal P&R Lot: An unstructured modal transfer location, typically not served by transit but providing a location for carpool and vanpool formation. These lots differ from formal park-and-pool lots in that they are not usually funded or supported by the transit agency or other governmental jurisdiction.

Opportunistic/Joint Use P&R Lot: A shared facility, where the park-and-ride lot is often the secondary use of the parking lot. Churches, government owned parking lots, and leftover land (e.g., under- and overpasses, unused portions of the median) provide opportunities for these lots. They may be served by transit.

Park-and-Pool Lot: A parking facility where individuals rendezvous to use carpools and vanpools as a transfer of mode, usually from their private automobiles. The facility is not served by public transportation.

Peripheral P&R Lot: A facility that provides additional parking for businesses and land uses primarily surrounding the lot or in proximity. These facilities may be unintentional consequences of poor facility location. They may be served by high levels of transit, but productivity measured by transit ridership from the lot may be low.

Remote Long-Distance P&R Lot: Lots located at greater distances from the primary activity center than the traditional suburban P&R lot. These facilities will often be located at the center of a smaller activity center, but provide parking and transit service to the distant primary center.

Satellite Parking Facilities: Park-and-ride lots placed on the perimeter of the primary activity center or central business center. These facilities are designed to provide relatively inexpensive parking for commuters accessing the activity center without having to travel into the center. These facilities may be served by transit.

Suburban P&R Lot: Park-and-ride lot typically located in outer portions of the urban area, primarily serving commute-to-work travel between the suburbs and the central city or other major activity center. Transit services may be extensive, with routes provided to multiple locations. Alternatively, more restricted transit providing service only to the primary business center within the region may be offered.

Peak Direction: The direction of higher demand during a peak commuting period. In a radial corridor, the peak direction has traditionally been toward the central business district in the morning and away from the central business district in the evening.

Peak Hour: That hour during which the maximum demand occurs for a given transportation corridor or region, generally specified as the morning peak hour or the evening peak hour.

Peak Period: A portion of the day in which the heaviest demand occurs for a given transportation corridor or region, usually defined as a morning or evening period of two or more hours.

Preferential Parking: Parking lots or spaces reserved exclusively for HOVs only as a means to encourage ridesharing. They are usually located closer to a terminal or building entrance than other vehicle spaces and may also have a reduced parking fee.

Preferential Treatment: In transportation, giving special privileges to a specific mode or modes of transportation (i.e., bus lanes or signal preemption at intersections).

Price Elasticity of Demand: A measure of the sensitivity of demand for a commodity to a change in its price. It equals the percentage change in consumption of the commodity that results from a 1-percent change in its price. The greater the elasticity, the more price-sensitive the demand for the commodity.

Priority Lane: Lane providing preferential treatment to eligible vehicles.

Priority Lane Pricing: Concept of using congestion pricing on an HOV lane.

Public Transit (or Public Transportation): Passenger transportation service to the public on a regular basis using vehicles that transport more than one person for compensation, usually but not exclusively over a set route or routes from one fixed point to another. Routes or schedules of this service may be predetermined by the operator or may be determined through a cooperative arrangement.

Queue: A line of waiting vehicles or persons. For example, traffic at a bottleneck location or signal, or buses at a park-and-ride facility, or persons in line to board a bus.

Queue Bypass HOV Facility: A short, often non-separated lane, designated to operate in the same direction as the adjacent general-purpose traffic lanes through an isolated traffic bottleneck, a toll plaza, or a metered location. The lane is designated for the exclusive use of HOVs and provides a “head-of-the-line” advantage in bypassing queued traffic (24).

Ramp Meter Bypass: A form of preferential treatment in which bypass lanes are provided at a ramp meter for the exclusive use of HOVs.

Ramp Metering: A system used to reduce congestion on a freeway facility by managing flow from on-ramps. An approach ramp is equipped with a metering traffic signal that allows the vehicles to enter a facility at a controlled rate.

Reversible Lane: A lane on which the direction of traffic flow can be changed to utilize maximum roadway capacity during peak demand periods.

Ridesharing: The function of sharing a ride with other passengers in a common vehicle. The term is usually applied to carpools and vanpools.

Road Pricing: An umbrella phrase that covers all charges imposed on those who use roadways. The term includes such traditional revenue sources as fuel taxes and license fees as well as charges that vary with time of day, the specific road used, and vehicle size and weight.

Signal Preemption: A technique for altering the sequence or duration of traffic signal phasing using vehicle detection in order to provide preferential treatment for buses and emergency vehicles.

Signal Priority: Technique of altering the sequence or timing of traffic signal phases using special detection in order to provide preferential treatment.

Single-occupant Vehicle (SOV): Any vehicle carrying only the driver.

Slip Ramp: A type of at-grade access that can be used at the beginning or end of an HOV facility that provides an acceleration/deceleration taper.

Spot HOV Treatments: Techniques that may be used to give HOVs priority around a specific bottleneck or with special access to a facility.

Study Period: The time during which a study is being conducted, which could be one or more parts of a day, all day, or more than a day.

Supporting Facilities: Facilities that provide for the safe and sheltered transfer of passengers between different travel modes, bus routes or services. General types of these facilities include park-and-ride and park-and-pool lots, transit stations, intermodal facilities, and bus stops and shelters.

Time-of-Day Pricing: Facility tolls that vary by time of day in response to varying congestion levels. Typically, such tolls are higher during peak periods when the congestion is most severe.

Toll Road: A road where motorists are charged a use fee (or toll). Toll roads may have preferential pricing for HOVs.

T-ramp: This direct (grade-separated) access ramp design gets its name because it forms the letter “T” between the HOV lane and the connecting park-and-ride lot or cross street.

Transit Center (or Transit Station): A mode transfer facility serving transit buses and other modes such as automobiles and pedestrians. In the context of this document, transit centers can provide premium park-and-ride services, allowing passengers to connect with a number of transit routes and other services.

Transit, Light Rail (LRT): An urban railway system characterized by its ability to operate single cars or short trains in streets or exclusive right-of-way, capable of discharging passengers at track or car floor level (TRB, Public Transportation Glossary, 1989).

Transponder: An electronic tag mounted on a license plate, built into a vehicle, or placed on the dashboard. The tag is read electronically by an electronic tolling device that automatically assesses the amount of the user fee.

Transportation Control Measures (TCM): A general term referring to transportation demand management (TDM), transportation systems management (TSM), and technology improvements that can be used to reduce regional emissions within a nonattainment area. Technology improvements can include more stringent vehicle emission testing requirements, old vehicle replacement programs, etc.

Transportation Demand Management (TDM): The operation and coordination of various transportation system programs to provide the most efficient and effective use of existing transportation services and facilities. TDM is one category of TSM actions.

Transportation Equity Act for the 21st Century (TEA-21): The Transportation Equity Act for the 21st Century was enacted June 9, 1998 as Public Law 105-178. TEA-21 authorizes the Federal surface transportation programs for highways, highway safety, and transit for the 6-year period 1998-2003.

Transportation System Management (TSM): Actions that improve the operation and coordination of transportation services and facilities to affect the most efficient use of the existing transportation system. Actions include operational improvements to the existing transportation system, new facilities, and demand management strategies.

Travel Time: The length of time it takes to travel between two points.

Travel Time Reliability: Term referring to the lack of variability in travel time that can be expected using different facilities.

Travel Time Savings: Time saved by using an HOV facility rather than the general-purpose lanes.

Value Pricing: A system of fees or tolls paid by drivers to gain access to dedicated roadway facilities providing a superior level of service compared to the competitive free facilities. Value pricing permits anyone to access the managed lanes, and the value of the toll is used to ensure that the management goals of the facility are maintained.

Vanpool: A prearranged ridesharing function in which a number of people travel together on a regular basis in a van, usually designed to carry six or more persons.

Violation Rate: The total number of violators divided by the total number of vehicles in HOV lane(s).

Volume to Capacity Ratio: The ratio of demand flow rates to capacity for a given type of transportation facility.

The definitions incorporated in this glossary were developed based on AASHTO, Parsons Brinckerhoff's Park-and-Ride Planning and Design Guidelines, recent managed lanes research sponsored by the Texas Department of Transportation, the 1989 TRB Public Transportation Glossary, Reference 24, and an on-line report describing TCRP Project A-23 entitled Implementation Guidelines for Bus Rapid Transit Systems.

Appendix C – List of Abbreviations

AASHTO: American Association of State Highway and Transportation Officials

ADA: Americans with Disabilities Act

ATMS: Advanced Traffic Management System

AVC: Automatic Vehicle Classification

AVI: Automated Vehicle Identification

AVL: Automatic Vehicle Location

AVO: Average Vehicle Occupancy

B/C: Benefit-cost Ratio

BRT: Bus Rapid Transit

CBD: Central Business District

CAAA: Clean Air Act Amendments

CCTV: Closed-circuit Television

DMS: Dynamic Message Signs

DOT: Department of Transportation (State or Federal)

EMS: Emergency Medical Services

EPA: Environmental Protection Agency

ETC: Electronic Toll Collection

FHWA: Federal Highway Administration

FTA: Federal Transit Administration

GIS: Geographic Information System

HCM: Highway Capacity Manual

HOT: High-occupancy Toll

HOV: High-occupancy Vehicle

ILEV: Inherently Low Emission Vehicle

ISTEA: Intermodal Surface Transportation Efficiency Act

ITE: Institute of Transportation Engineers

ITMS: Integrated Transportation Management Systems

ITS: Intelligent Transportation Systems

LOS: Level-of-service

LRT: Light Rail Transit

MOE: Measures of Effectiveness

MPO: Metropolitan Planning Organization

MUTCD: Manual on Uniform Traffic Control Devices

NAAQS: National Ambient Air Quality Standards

NCHRP: National Cooperative Highway Research Program

NEMA: National Electrical Manufacturer Association

NHS: National Highway System

NEPA: National Environmental Policy Act

P&P: Park-and-pool

P&R: Park-and-ride

ROW: Right-of-way

RRT: Rail Rapid Transit

SIP: State Implementation Plan

SOV: Single-occupant Vehicle

TCM: Transportation Control Measure

TCRP: Transit Cooperative Research Program

TDM: Transportation Demand Management or Travel Demand Management

TEA-21: Transportation Equity Act for the 21st Century

TIP: Transportation Improvement Program

TOD: Transit-oriented Development

TRB: Transportation Research Board

TSM: Transportation Systems Management

VMT: Vehicle Miles Traveled

vph: Vehicles per Hour

vphpl: Vehicles per Hour per Lane

Appendix D – Agency Contacts